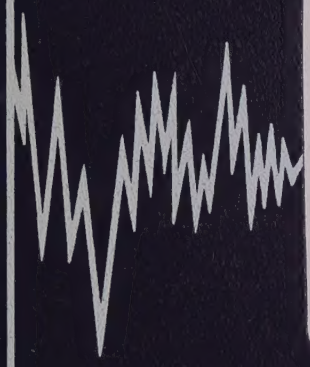
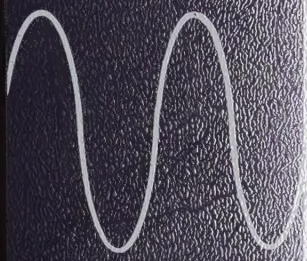
ELECTRO RENTS



INSTRUCTION MANUAL

CH9 LABS

SD104A-1
SWEEP OSCILLATOR



SPECTRAL DYNAMICS CORPORATION

SERIAL 1664

SDC F-20

INSTRUCTION MANUAL

SD104A-1
SWEEP OSCILLATOR

U. S. PATENT NO. 3,350,651

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June 1966

(Revised October 1971)

0/2

MANUAL CHANGES

Model: SD104A-1
Unit Serial: As Applicable
Manual Edition: - - -

Each change listed below must be individually analyzed for applicability in accordance with "Action" directed relative to unit serial number and/or documentation affected.

Change #1
ECO-1793
(5-7-74)

EFFECTIVITY: S/N 1593 and ON
ACTION: Schematic/Interconnecting Diagram, DWG. NO. 23066 (AB);

Change resistor R30 (located near the lower right corner on the schematic for Circuit Card A6) from 39k to 20k and add symbol ⚠ adjacent to it.

Change #2
ECO-1895
(10-2-74)

EFFECTIVITY: S/N 1663 and ON.
ACTION: Schematic/Interconnecting Diagram, DWG. NO. 23066 (AB);

1) On Circuit Card A3, add resistor R41, 51Ω, 1/4W, 5%, connected in series between C8 and the junction of Q3, Q4 and R16.
2) On Circuit Card A4, add resistor R42, 51Ω, 1/4W, 5%, connected in series between C10 and the junction of Q3, Q4 and R10.
3) On Circuit Card A5, add resistor R50, 51Ω, 1/4W, 5% connected in series between C8 and the junction of Q3, Q4 and R27.
4) On Circuit Card A6, add resistor R41, 51Ω, 1/4W, 5%, connected in series between C5 and the junction of Q3, Q4 and R18.

Change #3
ECO-1914
(10-31-74)

EFFECTIVITY: S/N 1663 and ON.
ACTION: Schematic/Interconnecting Diagram, DWG. NO. 23066 (AB);

On Circuit Card A1, change:
R30 from 31.6k, 1/2% to 30k, 1/8w, .1%,
R31 from 3.16k, 1/2% to 3k, 1/8w, .1%,
R32 from 243Ω, to 221Ω,
R33 from 100k to 5k.

Change #4
ECO-1991
(3-14-75)

EFFECTIVITY: S/N 1663 & On.
ACTION: Schematic/Interconnecting Diagram, DWG. NO. 23066 (AB); Circuit Card A8 (Sine Shaper Assembly 13020-3);

1) Delete capacitors C8 & C10.
2) Delete Resistor R27.
3) Change capacitor C6 from 30 pF to 5 pF, 500V, ±0.5 pF.
4) Change A1 from type μ709C to type 709HC.
5) Change A3 from type μ709C to type LM318H.

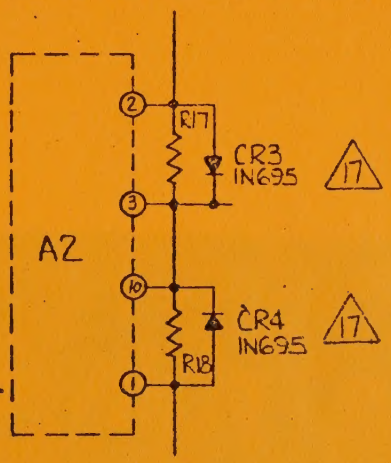
MANUAL CHANGES

Model: SD104A-1
Unit Serial: As Applicable
Manual Edition: - - -

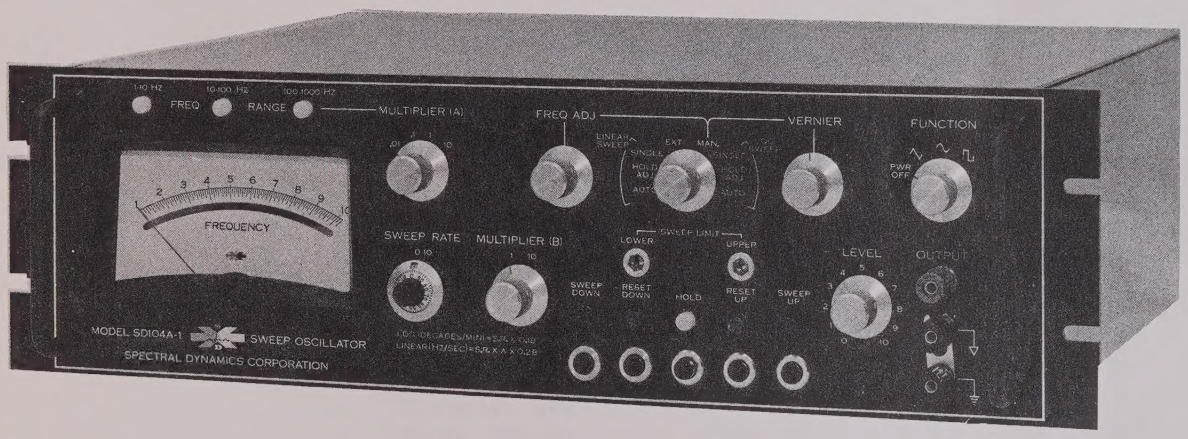
Each change listed below must be individually analyzed for applicability in accordance with "Action" directed relative to unit serial number and/or documentation affected.

Change #4 (Cont'd)

6) Add diodes CR3 & CR4 (IN695) in parallel with R17 & R18, respectively, connected as follows:



ADD NOTE 17 : FACTORY OPTIONAL.



MODEL SD104A-1 SWEEP OSCILLATOR

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SECTION I

GENERAL INFORMATION

1.1 SHIPPING AND INSPECTION PROCEDURE

The Model SD104A Sweep Oscillator is shipped fully assembled in a polystyrene case designed to protect it against all normal shipping hazards. Immediately upon receipt, it is recommended that an inspection be made of the exterior of the shipping case, making note of any apparent visible damage. Retain all forms and invoices attached to the shipping case and upon removal of the instrument, again note any apparent visible damage.

1.2 CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested for functional operation as soon as it is received in accordance with Section II of this manual. If damage in shipment is apparent, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report forwarded to Spectral Dynamics Corporation. The buyer will be advised of the disposition to be made of the equipment and arrangements shall be made for repair or replacement. Include name, model number and serial number when referring to the instrument for any reason.

1.3 WARRANTY POLICY

All Spectral Dynamics products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain components listed in some of the operating manuals, for the specified period. We will repair or replace products which prove to be defective during the warranty period, providing the failure or damage has not been caused by misuse or abnormal operating conditions. Fuses and lamps are specifically excluded from warranty. If the malfunction or a portion thereof is determined by Spectral Dynamics Corporation to have been caused by misuse or abnormal conditions of operation, an estimate of cost to repair will be submitted to the purchaser for approval before beginning any repair work.

Liability under this warranty is limited to servicing and adjusting the instrument returned to the factory, with transportation charges prepaid by the purchaser. No other warranty is expressed or implied. We are not liable for consequential damages.

If any malfunction develops, notify Spectral Dynamics Corporation or its representative in your area, giving details of the problem, and the name, model and serial number of the equipment. Upon receipt of this information, service data or shipping instructions will be provided.

1.4 RETURN SHIPMENT PROCEDURE

On receipt of shipping instructions, forward the instrument prepaid via air freight to the factory or authorized repair station indicated on the instructions. Replace the instrument in its original shipping case, or surround with two to three inches of shock absorbing material and then pack it in a heavyweight cardboard box, wooden box, or other strong container.

1.5 SPECIFICATIONS (Model SD104A-1)

This instrument has been carefully calibrated and inspected prior to shipment according to the following specifications:

Frequency

Range: 0.01 Hz to 10,000 Hz in four ranges as follows:

0.01 Hz	to	10 Hz
0.1 Hz	to	100 Hz
1.0 Hz	to	1000 Hz
10.0 Hz	to	10 kHz

Stability: 0.005% of full range, ±1% of frequency for a period of eight hours.

Sweep Limits: An upper and lower frequency limit may be preset electronically from the front panel. The upper frequency limit can be set anywhere in the upper decade of each range. The lower frequency limit can be set anywhere in the lower two decades of of each range.

Limit Accuracy: Upper limit - 0.5% of reading.
Lower limit - 0.5% of reading, ±0.02% of full range.

Display: Front panel meter with automatic range selection. Any single decade of the 3-decade ranges is displayed automatically in conjunction with indicator lights located above the meter.

Display Accuracy: 2% of reading after one-hour warmup.

Outputs

Available via BNC connectors on rear panel of chassis. Impedance: 600 ohms or less.

(1) Sine Wave (constant amplitude)

- Amplitude: 1 volt rms (approximately)
- Response: ±0.1 db, 0.01 Hz to 10 kHz
- Distortion: Less than 0.5%, 0.01 Hz to kHz ranges
  Less than 1%, 20 Hz to 10 kHz in 10 Hz to 10 kHz range
  Less than 1.5%, 10 Hz to 20 Hz in 10 Hz to 10 kHz range

(2) Square Wave (constant amplitude)

- Amplitude: 5 volts p-p (approximately)
- Response: ±0.02 db
- Rise and Fall Time: Less than 500 nanoseconds

(3) Triangle Wave (constant amplitude)

- Amplitude: 5 volts p-p (approximately)
- Response: ±0.25 db

1.5 SPECIFICATIONS (Cont'd)

Outputs

(4) Sine, Square or Triangle Wave (variable amplitude)

Selection:	Front panel switch
Amplitude:	Adjustable over a 50 db range from 10 volts p-p
Offset:	Adjustable, ±1.0 volt dc at full scale

(5) Positive dc-proportional-to-log frequency

Amplitude:	1 volt dc full range (approximately)
Accuracy:	±0.25 db after one hour warmup

(6) Positive and negative dc-proportional-to-linear frequency

Amplitude:	±10 volts dc full range (approximately)
Linearity:	±0.1% of full range

(7) Sweep Sync

Amplitude:	+3 volts pulse, minimum
Pulsewidth:	Approximately 0.5 milliseconds

The sweep sync pulse is generated at the beginning of each sweep and at each point where direction of sweep changes.

Sweep Modes

(1) Linear or logarithmic sweep rates with single or repetitive sweeps.

(2) External - may be driven from an external positive signal source for programming. Input impedance is 100k ohms. Positive 10 volts full range sensitivity. May be used in this mode as a dc log converter.

(3) Manual - the coarse and vernier frequency adjustments combine to provide ease of precise frequency setting.

(4) Hold - provides a short term stop of the sweep at any desired frequency.

(5) Reset - may be reset to either upper or lower limit for starting sweeps. Reset time is 3 seconds (approximately).

Sweep Rates

(1) Logarithmic - 0 to 10 decades/minute, continuously variable.

(2) Linear - 0 to 1000 Hz/second, continuously variable. Actual rate depends on frequency rate selected.

Sweep Rate Accuracy (for full 3-decade sweep)

Sweep Rate Control	Log Mode	Linear Mode
1 - 10	±3%	±1%
0.5 - 1.0	±5%	±3%
0.1 - 0.5	±10%	±10%
0 - 0.1	- - Usable but not calibrated - -	

Power: 115/230 volts ac, 50/60 Hz at approximately 20 watts

The SD104A is normally factory-wired for 115 volts ac operation. Refer to Schematic/Interconnecting Diagram for alternate wiring of power transformer T1 to provide for 230 volts ac operation.

Size: 5.25 in. x 19 in. standard rack front panel x 15 in. behind front panel (13,3 x 48,3 x 38,1 centimeters).

Weight: 25 lbs. (11,3 kilograms).

1.6 GENERAL DESCRIPTION

The Model SD104A is mounted on a 5¼" x 19" standard rack front panel and a chassis that extends 15" behind the front panel. All the modular type printed circuit card assemblies are easily accessible from the top of the chassis with the top cover removed.

With the exception of A10, Relay Switching Assembly 23044-1, each printed circuit card assembly is individually keyed to match a corresponding nylon key insert in a chassis-mounted female receptacle. Particular care should be exercised to ensure that assemblies A1 thru A9 and A11 thru A12 are NOT inserted in the receptacle provided for A10 at any time.

Although the printed circuit card plug-in assemblies currently in use number from A1 thru A12, provision has been made for future circuit card design in spaces labelled A13 thru A15. A connector has been installed in A15 as convenience housing for Circuit Card Extension Assembly 23060-1.

Rear chassis connectors J16, J17, J18 and J27 are not used in the standard models of the SD104A Sweep Oscillators. However, available as an optional feature is the "Wide Band Phase Shift Modification", which makes use of these connectors to provide four constant amplitude, fixed phase, sinewave outputs simultaneously (0°, 90°, 180° and 270°). This modification consists of two printed circuit card plug-in assemblies and associated wiring, identified as A14 and A15, and mating receptacles mounted on the top of the chassis.

(Rev. 8/20/69)

SECTION II

OPERATION

2.1 GENERAL

The front panel Mode Selector switch is color-coded and arranged according to four basic modes of operation; (1) EXTERNAL, (2) MANUAL, (3) LINEAR SWEEP, and (4) LOG SWEEP. All outputs are available at all times in any of the sweep modes. The dc-proportional-to-log frequency is available in all modes including the linear and logarithmic sweep modes.

> Before applying power to the instrument, set the meter mechanical-zero adjust screw so that the pointer is resting exactly on 1.

The power on-off switch for the instrument is the extreme counter-clockwise detent position of the front panel FUNCTION Selector. When this control is rotated clockwise to the next detent position (triangle wave), power is applied and there will be a time delay of approximately 20 seconds before any indication is noticed on the frequency meter. This is a normal time delay feature designed to protect the instrument against current surges.

2.2 FREQUENCY METER AND MULTIPLIER (A) SWITCH

The frequency meter, in conjunction with the MULTIPLIER (A) switch and the decade indicator lamps located above the meter, provides a reading of the actual frequency being produced by the SD104A. To illustrate, assume that the MULTIPLIER (A) switch is in the 1 position. When the decade indicator lamp to the far left is on, the meter scale covers a range of 1 to 10 Hz. When the middle decade indicator lamp is on, the meter scale covers a range of 10 to 100 Hz. When the decade indicator lamp to the far right is on, the meter scale covers a range of 100 to 1000 Hz. This automatic switching action is in the meter circuitry ONLY and in no way affects the internal operation of the instrument or any of its outputs. Hysteresis has been built into the meter switching to facilitate the setting of any frequency at the extremes of the calibrated scale.

Four multiples of the three basic ranges are obtainable by rotating the MULTIPLIER (A) switch and multiplying the meter reading by the position selected.

Example: The meter indicates 5; the middle decade lamp is on; MULTIPLIER (A) is in the 0.01 position.

The frequency is: 50 x 0.01 = 0.5 Hz

Example: The meter indicates 5; the decade lamp to the far right is on; MULTIPLIER (A) is in the 10 position.

The frequency is 500 x 10 = 5,000 Hz

2.3 FREQUENCY ADJUST AND VERNIER CONTROLS

The FREQ ADJ and VERNIER controls set the operating frequency of the SD104A when in the MAN. position of the Sweep Mode Selector. The FREQ ADJ control by itself will normally have sufficient resolution. However, the VERNIER control, with 10 times greater resolution, will be useful in setting the SD104A to a particular frequency.

2.4 FUNCTION SELECTOR SWITCH

A FUNCTION Selector switch in the upper right-hand corner of the front panel permits the operator to select one of three types of outputs (triangle, sine or square wave) available at the front panel OUTPUT terminals and at J22, BNC rear chassis connector. The extreme counter-clockwise detent position of this switch turns the power off to the instrument.

2.5 LEVEL CONTROL

The amplitude of the output at the front panel OUTPUT terminals and at J22, BNC rear chassis connector, is determined by the setting of the front panel LEVEL control, within the range of 30 millivolts to approximately 10 volts peak-to-peak.

2.6 SWEEP RATE AND MULTIPLIER (B) CONTROLS

When sweeping logarithmically as a sweeping oscillator, the sweep speed, in decades/minute,* is determined by multiplying the setting of the SWEEP RATE control by the MULTIPLIER (B) switch position, and multiplying the product by 0.1.

Formula: Log (dec/min) = SWEEP RATE x MULTIPLIER (B) x 0.1

Example: To sweep logarithmically at a rate of 0.06 decades/minute, set the SWEEP RATE control at 0.6 and the MULTIPLIER (B) switch at 1. (The sweep mode switch must be in a LOG SWEEP position).

Solution: 0.6 x 1 x 0.1 = 0.06 dec/min

When sweeping linearly, the sweep speed in Hz/sec is determined by multiplying the setting of the SWEEP RATE control by the MULTIPLIER (B) switch position, and multiplying the product by the MULTIPLIER (A) setting.

Formula: Lin (Hz/sec) = SWEEP RATE x MULTIPLIER (B) x MULTIPLIER (A) x 0.2

Example: To sweep linearly at a rate of 0.15 Hz/sec with the MULTIPLIER (A) switch set at 0.1, set the SWEEP RATE control at 7.5 and MULTIPLIER (B) switch at 1. The sweep mode switch must be in a LINEAR SWEEP position.)

Solution: 7.5 x 1 x 0.1 x 0.2 = 0.15 Hz/sec

*See formula, paragraph 2.12, page 13, for determining number of decades between two frequency limits.

2.6 SWEEP RATE AND MULTIPLIER (B) CONTROLS (Cont'd)

For best sweep rate accuracy, set MULTIPLIER (B) at 1 whenever possible.

Example: A log sweep rate of 0.6 decades/minute may be programmed two different ways:

(1) Set SWEEP RATE to 0.6 and MULTIPLIER (B) to 10.

Log (dec/min) = 0.6 x 10 x 0.1 = 0.6 dec/min

(2) Set SWEEP RATE to 6.0 and MULTIPLIER (B) to 1.

Log (dec/min) = 6.0 x 1 x 0.1 = 0.6 dec/min

By formula, both of the above operations give the same sweep rate, but circuit design considerations allow the accuracy of (2) above to be specified as ±3% of setting, whereas (1) above is specified as ±5% of setting. Refer to specifications for Sweep Rate Accuracy (percent of setting).

2.7 SWEEP MODE SWITCH AND PUSHBUTTONS

The following is a detailed explanation of the various positions of the Sweep Mode Switch and use of the pushbutton controls.

MANUAL MODE

In the MAN. mode the SD104A acts as a variable frequency oscillator. After setting MULTIPLIER (A) to the desired frequency range, any frequency within that range may be obtained by turning the FREQ ADJ control, utilizing the VERNIER control when necessary for greater resolution. Both the FREQ ADJ and VERNIER will have to be turned fully counter-clockwise to obtain the lowest frequency in any given range.

Example: To obtain 72 Hz in the manual mode:

(1) Set sweep mode selector to MAN.
(2) Set MULTIPLIER (A) to 1 (1 Hz to 1000 Hz).
(3) By means of the FREQ ADJ control, obtain a reading of 7.2 on the frequency meter with the middle decade lamp on.

EXTERNAL MODE

In the EXT mode the SD104A acts as a Voltage-Controlled Oscillator (VCO) controlled by the dc voltage applied to J29 on the rear of the chassis. This dc voltage should be limited to the range of +10 millivolts to +10 volts. The frequency meter, in conjunction with the setting of the MULTIPLIER (A) switch, will indicate the VCO frequency. All of the SD104A outputs are functional and in this mode the instrument may be used as a highly accurate dc log converter. The dc output at J24 will be proportional to the log of the applied dc voltage, ±0.25 db.

2.7 SWEEP MODE SWITCH & PUSHBUTTONS (Cont'd)

UPPER & LOWER LIMIT ADJUSTMENTS

The setting of the upper and lower frequency limits may be done from the front panel after selection of the desired operating mode. To set the lower limit, push the RESET DOWN pushbutton and turn the LOWER screwdriver adjustment until the desired lower limit frequency is indicated on the meter. The same procedure may be used for setting the upper limit using the RESET UP pushbutton and the UPPER screwdriver adjustment. When switching from LOG SWEEP to LINEAR SWEEP, or vice versa, the lower limit must be reset.

SINGLE SWEEP MODE (LOG OR LINEAR)

In this mode the SD104A will sweep once from the lower limit to the upper limit or vice versa. For example; to sweep once from the lower limit to the upper limit, set the sweep mode selector to SINGLE LOG or LINEAR SWEEP and push the RESET DOWN pushbutton. It will automatically reset to the preset lower frequency limit. When the lower limit is reached, push the SWEEP UP pushbutton, thereby actuating a single "UP" sweep. When the upper limit is reached, the sweep will stop and the RESET UP lamp will light.

To sweep once from the upper limit to the lower limit, push the RESET UP pushbutton. It will automatically reset to the preset upper limit. When the upper limit is reached, push the SWEEP DOWN pushbutton, thereby actuating a single "DOWN" sweep. When the lower limit is reached, the sweep will stop and the RESET DOWN lamp will light.

AUTO SWEEP MODE (LOG OR LINEAR)

In this mode the SD104A will sweep repetitively between the upper and lower limits. This repetitive sweeping may be initiated from either the upper or the lower limit in the same manner as in the single sweep mode. A minimum frequency difference between the upper and lower limits of 3% of full range must be maintained. In addition, the lower limit must always be set at a lower frequency than the upper limit, otherwise the relay logic may "lock-up".

HOLD ADJUST MODE (LOG OR LINEAR)

In the HOLD ADJ mode the SWEEP UP and SWEEP DOWN pushbuttons may be used like "elevator" controls. The SD104A will sweep up as long as the SWEEP UP pushbutton is depressed, and will stop as soon as the pushbutton is released. This action is identical for sweeping down. To place the SD104A in the HOLD ADJ mode, push the HOLD pushbutton when operating in either single or automatic sweep and then turn the sweep mode selector to the HOLD ADJ position.

HOLD FUNCTION

To stop any single or automatic sweep, depress the HOLD pushbutton. The SD104A will remain in HOLD until another button is depressed or the sweep mode selector is moved, and at the frequency that existed just before the HOLD button was depressed. A slight amount of drift in this mode is normal.

2.8 TYPICAL OPERATION

Assume that a single linear sweep from 0.2 Hz up to 10 Hz is desired with a sweep rate of 0.1 Hz/sec. Set MULTIPLIER (A) at 0.01 (0.01 to 10 Hz range), MULTIPLIER (B) at 10 and SWEEP RATE control at 5.

By formula, the sweep rate is:

$$\text{Lin (Hz/sec)} = 5.0 \times 10 \times 0.01 \times 0.2 = 0.1 \text{ Hz/sec}$$

Set Sweep Mode switch to SINGLE LINEAR SWEEP. Depress the RESET UP pushbutton and adjust for a reading of 12 in the highest decade (1000 x 0.01 = 10 Hz). Depress the RESET DOWN pushbutton and adjust for a reading of 2 in the lowest decade (20 x 0.01 = 0.2 Hz). To initiate the single "UP" sweep, depress the SWEEP UP pushbutton. The total time required for the sweep will be:

$$\text{Sweep Time} = \frac{\text{frequency difference}}{\text{sweep rate}} \text{ or } \frac{10 - 0.2}{0.1} = 98 \text{ sec.}$$

As stated in the specifications, the SWEEP RATE control is usable from 0 to 0.1, but it is not calibrated over this range. Very slow sweep rates may be obtained in this range using the cut-and-try method. With the control set at 0, the sweep circuit is actually in the HOLD mode as far as frequency sweep is concerned. With practice, an operator can slow the sweep down gently to a complete stop and then continue on as desired.

2.9 AUXILIARY FUNCTIONS

Rear Chassis connector J30 (AUX FUNCTIONS) and toggle switch S12 (SWEEP RATE INT-EXT) as applicable, provide certain additional interconnecting circuitry as follows:

J30 Pin Designation	Description/Function
A & B	External series-interlock connections. Used for connection to the interlock circuitry of a vibration exciter control servo (see paragraph 2.10).
C	Interlock/Hold. For use with external interlock circuitry (see paragraph 2.11).
D	+15 volts dc, regulated. Source impedance 1000 ohms. Short-circuit proof.
E	-15 volts dc, regulated. Source impedance 1000 ohms. Short-circuit proof.
F	Negative dc proportional to output frequency.
G	Circuit ground.

2.9 AUXILIARY FUNCTIONS (Cont'd)

J30

Pin Designation	Description/Function
H	Sweep control voltage from internal sweep circuit. Connected internally to Sweep Integrator when S12 is in the INT position. Source impedance 1000 ohms or less. Short-circuit proof. Output voltage & polarity dependent on sweep speed & direction settings.
J	Input to the Sweep Integrator circuit. Used for external control of sweep rate & direction. Maximum permissable input voltage is positive or negative 10 volts dc. Input impedance 1.8 megohms in LOG mode; 5 megohms in LINEAR mode.
L	Positive or negative 15 volts dc, regulated, depending on direction of sweep. Negative 15 volts dc for UP SWEEP; positive 15 volts dc for DOWN SWEEP. May be used for general instrumentation applications. Provides required dc input for SDC Model SD27 multi-filter selector used in conjunction with Spectral Dynamics tracking filters and dynamic analyzers. Current drawn from J30-L must not exceed 50 milliamps. A short circuit will not damage the instrument but will cause it to be inoperative until the short is removed. This circuit connects directly to the positive or negative dc supply. Output impedance is less than 1 ohm.
b & c	External relay sense circuit interconnections.

The SWEEP RATE INT-EXT switch S12, located on the rear of the chassis just above J30, determines whether the SD104A sweep rate and direction are controlled internally (front panel), or externally via pin J of J30. For all normal operation, this switch should be set in the INT position.

2.10 INTERLOCK

When using the Model SD104A Sweep Oscillator and the Model SD105 Amplitude Servo/Monitor in combination as an excitation source for electrodynamic or hydraulic shaker systems, changing the position of certain front panel switches on either unit while a test is in progress could cause destructive transients to occur. To preclude the possibility of damage to the system or the specimen as a result of "turning the wrong knob", special interlock circuitry is incorporated in the Model SD105 Amplitude Servo/Monitor that will cause the output of the SD105 to smoothly and rapidly decay to a safe level (At least 70 db from full output, at a rate determined by the compressor speed). An extension of this feature has been added to the Model SD104A Sweep Oscillator.

2.10 INTERLOCK (Cont'd)

In the case of the Model SD104A, the interlock circuitry consists of a series-connected loop between pins A & B of rear connector J30, and involves the following front panel controls:

(1) Sweep Mode Selector (S2)

(2) MULTIPLIER (A) Switch (S1)

(3) RESET UP Pushbutton (S8)

(4) RESET DOWN Pushbutton (S6)

Figure 1 shows the interlock closed-loop circuit within the Model SD104A. Note: Due to make-before-break switch action, interlock will not occur when switching the Mode Selector (S2H) within the SINGLE, HOLD ADJ or AUTO positions of either the LINEAR SWEEP or the LOG SWEEP modes of operation. However, interlock will occur when switching out of either the LINEAR SWEEP or LOG SWEEP modes and between the EXT and MAN. positions.

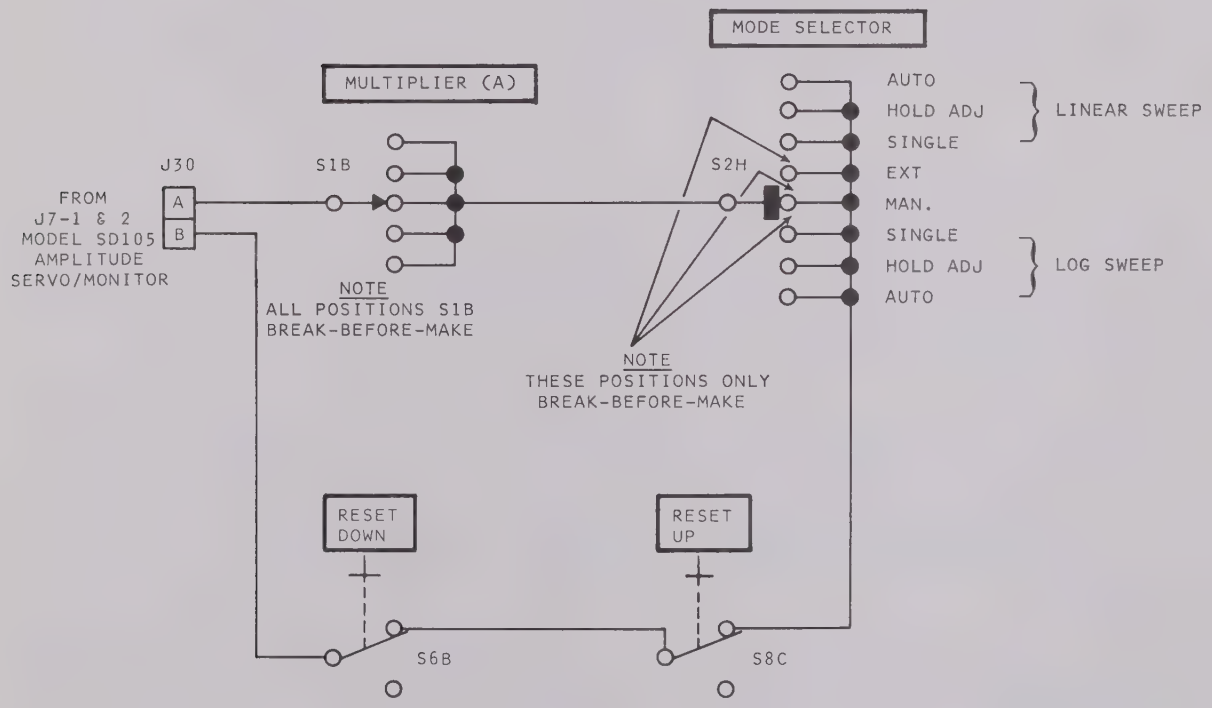


Figure 1. Model SD104A Interlock Circuit

2.10 INTERLOCK (Cont'd)

After the proper connections have been made from J30-A & J30-B of the Model SD104A to J7-1 & J7-2 of the Model SD105, the complete interlock circuit of both units should be thoroughly checked prior to actual operation with a shaker system. This may be done by connecting the SD105 SERVO OUTPUT (J6) to the SD105 ACCEL NO. 1 input (J8) and then switching each critical front panel control on both units, one at a time, to make certain that the system will, in fact, go into interlock.

CAUTION

Extreme care should be exercised if an attempt is made to use the SD104A/SD105 interlock circuit for any function other than that mentioned in the previous paragraphs.

For example: Additional normally-closed contacts within the system could conceivably be connected in series with the normal interlock circuit, provided the contacts are not a part of another circuit that would introduce a voltage or a current into the interlock loop. If in doubt about a particular application, contact Customer Services Department of Spectral Dynamics Corporation.

2.11 INTERLOCK/HOLD

In addition to the method discussed in paragraph 2.7, the HOLD mode may be activated remotely by connecting pin J30-C to pin J30-G(circuit ground). This causes the same action as pushing the front panel HOLD pushbutton. The SD104A will remain in the HOLD mode as long as J30-C is grounded.

This remote HOLD feature may be combined with the SD104A/SD105 INTERLOCK function so that whenever the interlock circuit is activated, the SD104A will stop sweeping and go into the HOLD mode. It will remain in the HOLD mode until the cause of interlock action has been corrected, the SD105 has been properly reset, and the appropriate SD104A SWEEP UP or SWEEP DOWN pushbutton has been depressed.

To use this combined SD104A/SD105 INTERLOCK/HOLD feature, connect the SD104A J30-C to the SD105 J30-11, and the SD104A J30-G to the SD105 J30-10.

2.12 SWEEP RATE CONVERSION

The following table converts the decades-per-minute sweep rate of the Model SD104A Sweep Oscillator to its equivalent in degrees-per-minute as related to the tuning dial commonly used on Bruel & Kjaer automatic vibration exciter controllers.

DECADES PER MIN.	DEGREES PER MIN.
.04	2.88
.05	3.60
.06	4.32
.07	5.04
.08	5.76
.09	6.48
.1	7.2
.2	14.4
.3	21.6
.4	28.8
.5	36.0
.6	43.2
.7	50.4
.8	57.6
.9	64.8
1.0	72.0
2.0	144.0
3.0	216.0
4.0	288.0
5.0	360.0
6.0	432.0

In addition, the following formula may be used to convert octaves-per-minute to decades-per-minute:

$$\text{Decades/Minute} = \frac{\text{X Octaves/Minute}}{3.32}$$

Where: X = Number of octaves-per-minute

The following formula may be used to determine the number of decades between two frequency limits:

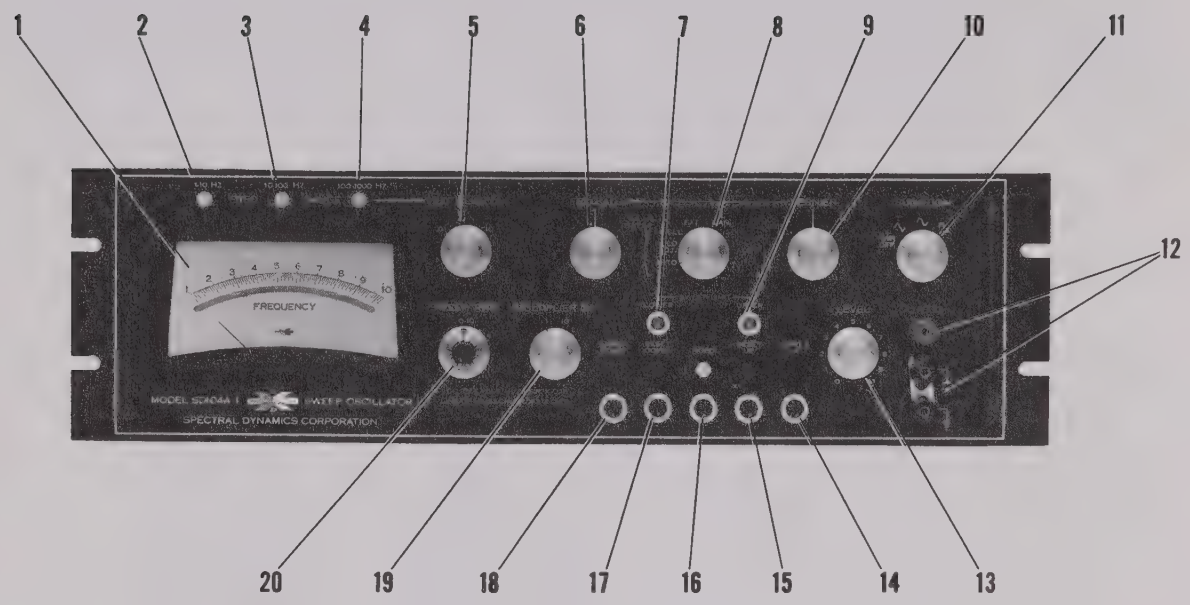
$$\text{Decades} = \text{Log}_{10} \frac{F_2}{F_1}$$, Where F_1 is the lower frequency limit and F_2 is the higher frequency limit.

Problem: Determine the number of decades between 5 Hz & 2000 Hz.

Solution: $\text{Decades} = \text{Log}_{10} \frac{F_2}{F_1} = \text{Log}_{10} \frac{2000}{5} = \text{Log}_{10} 400 = 2.602$

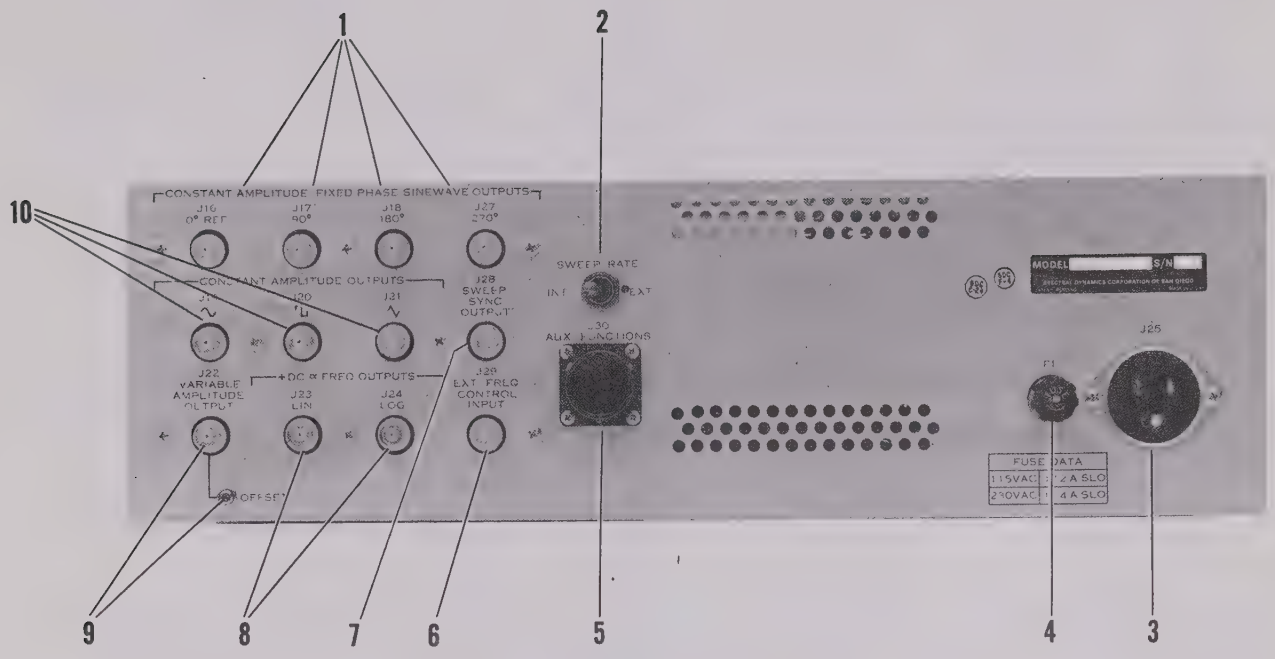
Answer: 2.602 Decades

NOTE: In lieu of the above formula, the same result may be obtained using the Frequency-To-Decade Conversion Table on Page 16.



1	FREQUENCY METER (M1)	11	FUNCTION SELECTOR (S7)
2	DECADE INDICATOR LAMP (1-10 Hz)	12	OUTPUT/GND TERMINALS (J26)
3	DECADE INDICATOR LAMP (10-100 Hz)	13	OUTPUT LEVEL CONTROL (R1)
4	DECADE INDICATOR LAMP (100-1000 Hz)	14	SWEEP UP PUSHBUTTON (S9)
5	MULTIPLIER (A) SWITCH (S1)	15	RESET UP PUSHBUTTON (S8)
6	FREQUENCY ADJUST (R36)	16	HOLD PUSHBUTTON (S5)
7	LOWER SWEEP LIMIT ADJUST (R29)	17	RESET DOWN PUSHBUTTON (S6)
8	SWEEP MODE SELECTOR (S2)	18	SWEEP DOWN PUSHBUTTON (S10)
9	UPPER SWEEP LIMIT ADJUST (R33)	19	MULTIPLIER (B) SWITCH (S13)
10	VERNIER FREQUENCY ADJUST (R2)	20	SWEEP RATE CONTROL (R50)

Figure 2. Front Panel View



1 CONSTANT AMPLITUDE, FIXED PHASE, SINEWAVE OUTPUTS (OPTIONAL) (J16, J17, J18, J27)

2 INTERNAL-EXTERNAL SWEEP RATE SWITCH (S12)

3 POWER INPUT (J25)

4 FUSE (F1)

5 AUXILIARY FUNCTIONS (J30)

6 EXTERNAL FREQUENCY CONTROL INPUT (J29)

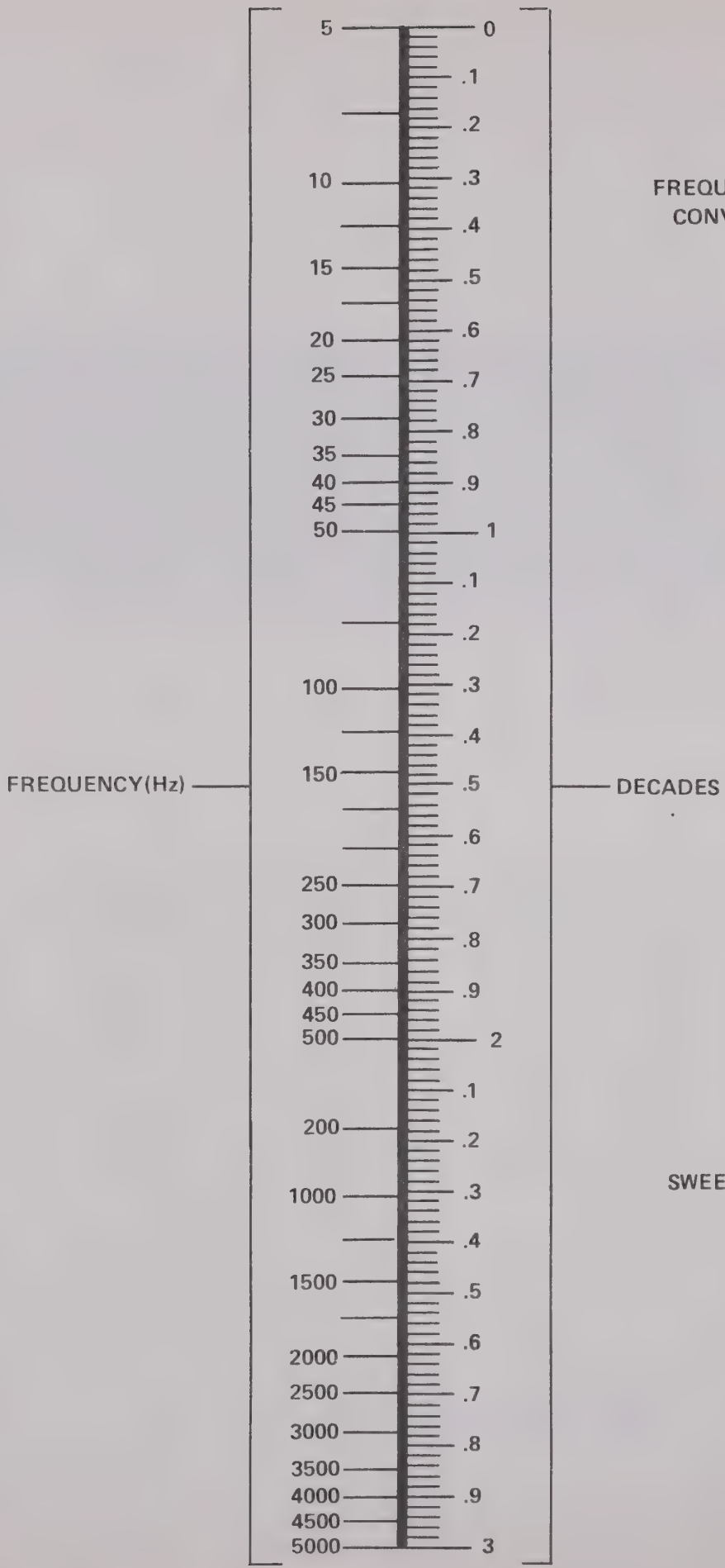
7 SWEEP SYNC OUTPUT (J28)

8 +DC-PROPORTIONAL-TO-FREQUENCY OUTPUTS - LINEAR & LOG (J23, J24)

9 VARIABLE AMPLITUDE OUTPUT & OFFSET ADJUST (J22 & R31)

10 CONSTANT AMPLITUDE OUTPUTS - SINE, SQUARE & TRIANGLE WAVE (J19, J20, J21)

Figure 3. Rear Chassis View



FREQUENCY-TO-DECADE CONVERSION TABLE

$$\text{SWEEP RATE} = \frac{\text{DECADES}}{\text{TIME}}$$

(Rev. 10/68)

SECTION III

THEORY OF OPERATION

3.1 INTRODUCTION

The theory of operation for the Model SD104A Sweep Oscillator may be divided into the two basic functions of the instrument: (1) A Ramp Generator and (2) a precision Voltage Controlled Oscillator driven by the Ramp Generator. For the discussion contained in the following paragraphs, refer to the Simplified Block Diagram, Figure 4, which shows a Model SD104A sweeping in the automatic linear sweep mode.

3.2 RAMP GENERATOR

Amplifier #1 is an operational integrator that produces a ramp voltage. The slope of the ramp it produces is determined by the SWEEP RATE control, and the voltage from MULTIPLIER (B) through K1. The voltage supplied by K1 to the integrator is reduced to 1/10th its original value when MULTIPLIER (B) is in the 1 position, thereby providing even slower sweep speeds.

Assuming that K1 is not energized, a negative voltage is supplied to the SWEEP RATE potentiometer, causing a positive going ramp at point A. Amplifiers #2 and #3 are inverter amplifiers with a gain of 1. The UPPER LEVEL SWITCH is a voltage comparator that generates a pulse when the voltage at point C exceeds the voltage from the UPPER LIMIT potentiometer. When this occurs, the bistable multivibrator changes state, energizing K1, which in turn supplies a positive voltage to the integrator, causing the ramp to have a negative going slope and the process repeats itself.

A voltage from the LOWER SWEEP LIMIT potentiometer is summed into amplifier #2, creating an offset voltage and determines the lowest voltage (lowest frequency of the VCO) to which the SD104A will sweep.

The negative dc-proportional-to-frequency signal at point B is available at J30-F and drives the LOG CONVERTER. The log converter produces a positive voltage that is proportional to the logarithm of the negative dc voltage and is proportional to the logarithm of the frequency produced by the SD104A. The log voltage is available at J24. The positive dc-proportional-to-frequency signal at point C drives the VCO and the meter circuitry, and is available at J23.

The meter switching circuit selects the correct meter attenuator and the corresponding decade indicator lamp as the positive dc-proportional-to-frequency changes. The decade indicator lamp to the far left will glow between 10 millivolts and 100 millivolts, the middle decade indicator lamp will glow between 100 millivolts and 1 volt, and the decade indicator lamp to the far right will glow between 1 volt and 10 volts. The additional set of contacts on relay K1 energizes the SWEEP UP and SWEEP DOWN indicator lamps.

3.3 VOLTAGE CONTROLLED OSCILLATOR (VCO)

The VCO is a high speed integrator that runs between an upper and lower voltage level to produce a triangle wave. The time constant of this integrator (Amplifier #4) is set by the value of R3 (fixed) and the particular capacitor selected by MULTIPLIER (A) on the front panel. The slope of the triangle wave produced by Amplifier #4 is determined by the time constant selected and the polarity and magnitude of the dc voltage at point D. The FREQUENCY CONTROLLED SWITCH passes either the positive or the negative dc-proportional-to-frequency signal, depending on the polarity of the square wave at point F. The UPPER LEVEL SWITCH and the LOWER LEVEL SWITCH are set to trigger at plus and minus 5 volts, respectively.

Assume that the bistable multivibrator is deenergized and the square wave at point F is negative. This negative voltage will cause the FREQUENCY CONTROLLED SWITCH to pass the negative dc-proportional-to-frequency signal through R3 to Amplifier #4 and cause a positive-going ramp at point E. When this ramp reaches a positive 5 volts, the UPPER LEVEL SWITCH will trigger and energize the bistable multivibrator. The voltage at point F will then be positive and the frequency controlled switch will pass the positive dc-proportional-to-frequency signal, causing a negative going ramp at point E. When this ramp reaches a negative 5 volts, the LOWER LEVEL SWITCH will trigger and deenergize the bistable multibrator. This process repeats itself, creating a triangle wave at point E. For a fixed setting of MULTIPLIER (A), the frequency of the triangle wave will be directly proportional to the magnitude of the dc supplied by the Ramp Generator.

The square wave at point F and the triangle wave at point E are buffered and available at BNC rear chassis connectors J20 and J21, respectively.

The triangle wave at point E also drives the SINE SHAPER, providing a sine wave of the same frequency as the triangle wave at connector J19.

Amplifier #5 is a variable gain, variable offset, constant output impedance amplifier. The front panel FUNCTION switch permits the selection of a triangle, sine or square wave output, available at the front panel OUTPUT terminals or at the BNC rear chassis connector J22.

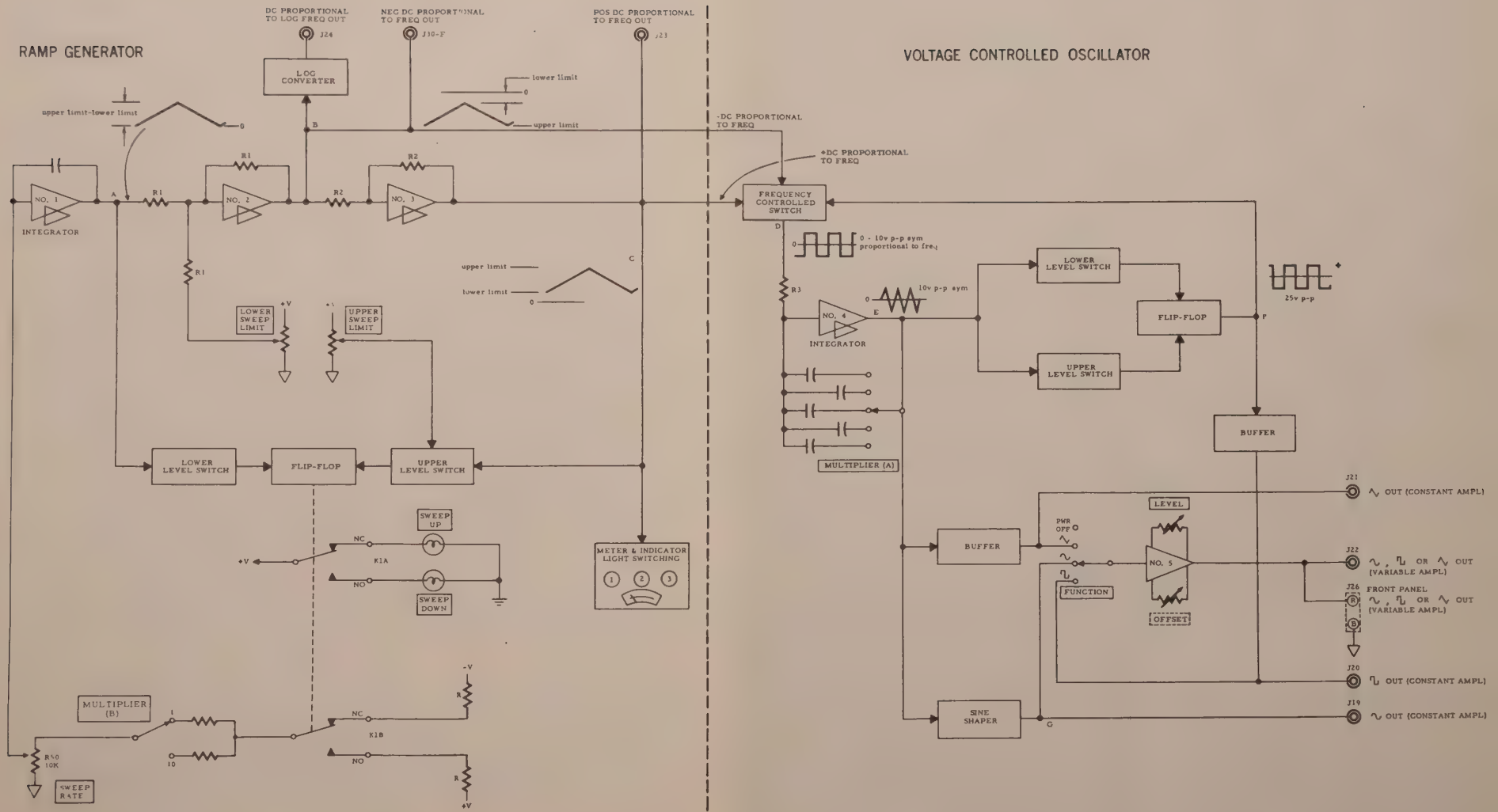


Figure 4. Simplified Block Diagram

SECTION IV

CALIBRATION

4.1 INTRODUCTION

The Model SD104A Sweep Oscillator has been carefully calibrated at the factory. However, after prolonged use or major parts replacement, it may be necessary to recalibrate in accordance with the procedure contained in this section.

Test points and adjustments are referred to throughout the calibration procedure by the use of the combined circuit card reference designations and the component reference designations. For example, reference to R12 on circuit card A6 will be noted as A6R12; TP3 on circuit card A6 will be noted as A6TP3.

Furnished with the instrument and housed in convenience-receptacle J15 is a circuit card extender assembly. The use of this extender assembly makes the various test points and calibration adjustments on circuit cards A1 through A12 easily accessible. However, in order to plug the extender card into any of the regular receptacles, one or two nylon "key" inserts must first be removed from the selected receptacle (except J10). The key inserts may be located by the black dots on the chassis adjacent to each receptacle's insert(s) Use a pair of long-nose pliers to remove the insert(s) and replace the insert(s) after the extender card is removed.

CAUTION

Always disconnect the ac power cord from the instrument when removing and replacing circuit card assemblies.

Unless otherwise directed, the digital voltmeter used throughout the following calibration procedure should be grounded to the ground buss common to the rear chassis BNC connectors.

4.2 METER

Before applying power to the instrument, set the meter mechanical zero-adjust screw so that the pointer of the meter is resting exactly on 1.

4.3 POWER SUPPLY

Connect ac line power to the unit and rotate the front panel FUNCTION switch clockwise, turning the unit on. With the digital voltmeter connected to A12TP2, adjust A12R16 for negative 15 volts dc. Connect the voltmeter to A12TP3 and adjust A12R8 for positive 15 volts dc.

Using an oscilloscope, measure the ac ripple at A12TP2 and A12TP3. Ripple should not exceed 1.5 millivolts peak-to-peak, referenced to circuit ground.

4.4 METER CALIBRATION

Mount circuit card A1 on the circuit card extender assembly and plug it into receptacle J1. Set the front panel mode switch to the MAN. position and the FREQ ADJ and VERNIER controls to their extreme counter-clockwise positions. Ground the digital voltmeter directly to some point originating from pin 20 of circuit card A1.

Measure the voltage at A1TP1, which should be positive 10 millivolts, ±1.0 millivolt. At A1TP2 it should be 100 millivolts, ±1 millivolt, and at A1TP3, 1 volt, ±0.01 volt.

Remove circuit card extender assembly and replace circuit card A1 in receptacle J1.

Connect the digital voltmeter to J23, BNC rear chassis connector, and with the FREQ ADJ and VERNIER controls on the front panel, set the dc-proportional-to-frequency voltage to 9.999 volts. Adjust the SHUNT potentiometer A1R33 for a reading of 10 on the front panel frequency meter, with the decade indicator lamp to the far right (highest decade) illuminated.

Set the dc-proportional-to-frequency voltage to 100 millivolts and adjust SERIES potentiometer A1R34 for a reading of 10 on the front panel frequency meter, with the decade lamp to the far left (lowest decade) illuminated. If A1R34 has insufficient range to set the meter correctly, select a different value for A1R32 that will allow this adjustment to be made.

Repeat the previous two steps until both conditions are properly met.

Adjust 2ND DECADE potentiometer A1R21 so that the decade indicator lamps switch from the lowest decade to the middle decade just as the meter pointer reaches 10.2 (last marked division), as the FREQ ADJ control is slowly brought through this point in a clockwise direction.

Adjust 3RD DECADE potentiometer A1R10 so that the decade indicator lamps switch from the middle decade to the highest decade just as the meter pointer reaches 10.2 (last marked division), as the FREQ ADJ control is slowly brought through this point in a clockwise direction.

4.5 CHOPPER DRIVE

Adjust DRIVE potentiometer A11R10 for 3.4 volts peak-to-peak at A11TP3, as measured with an oscilloscope.

4.6 UP RESET SERVO

Mount circuit card A10 on the extender assembly and plug it into receptacle J10. Place the front panel mode switch in the SINGLE LINEAR SWEEP position and depress the RESET UP pushbutton. Connect a digital voltmeter to A10TP1 and rotate the UPPER LIMIT front panel control fully counterclockwise, noting the reading on the voltmeter. Connect the voltmeter to A10TP2 and adjust OFFSET potentiometer A10-

4.6 UP RESET SERVO (Cont'd)

R10 for the same reading, but of opposite polarity.

Reconnect the voltmeter to A10TP1 and adjust the UPPER LIMIT front panel control for a reading of approximately 9 volts, and note this reading. Reconnect the voltmeter to A10TP2 and adjust the BALANCE potentiometer A10R15 for the same reading, but of opposite polarity. Repeat until the voltage at A10TP1 tracks the voltage at A10TP2 within 2 millivolts.

Remove circuit card extender assembly and replace circuit card A10 in receptacle J10.

4.7 OFFSET ADJUSTMENT

Set the front panel mode switch to the MAN. position. Connect the digital voltmeter to the rear terminal lug (wiper) of the FREQ ADJ potentiometer and rotate both the FREQ ADJ and VERNIER controls as necessary to obtain a reading of 10 millivolts.

Connect the voltmeter to J30-F and adjust OFFSET potentiometer A5R17 for negative 10 millivolts.

Connect the voltmeter to J23 and adjust OFFSET potentiometer A3R8 for positive 10 millivolts.

Mount circuit card A6 on the circuit card extender assembly and plug it into receptacle J6. Set the mode switch in the SINGLE LINEAR SWEEP position and depress the RESET DOWN pushbutton. Connect the digital voltmeter to A6TP2 and adjust OFFSET potentiometer A6R10 for a reading of zero, ±0.02 millivolts.

Repeat the preceding adjustments as necessary & recheck the measurements to ensure that the settings of the OFFSET potentiometers are correct.

Remove circuit card extender assembly and replace circuit card A6 in receptacle J6.

4.8 TRIANGLE WAVE ADJUSTMENT

With mode switch in the MAN. position, set FREQ ADJ control for a meter indication with middle decade indicator lamp lit. Set MULTIPLIER (A) to the .1 position and connect scope probe to A4TP2. Note: Scope must be calibrated and used in dc-coupled mode.

Adjust UPPER control A2R1 until upper peak of triangle wave is exactly 5 volts above ground. Adjust LOWER control A2R3 until negative peak of triangle wave is exactly 5 volts below ground.

4.9 SYMMETRY ADJUSTMENT

Set the mode switch to the MAN. position and both the FREQ ADJ and the VERNIER controls fully counter-clockwise. Turn the LEVEL control

4.9 SYMMETRY ADJUSTMENT (Cont'd)

fully clockwise. With front panel FUNCTION switch, select the square wave output and set MULTIPLIER (A) in the 10 position. Monitoring the front panel output terminals with an oscilloscope, adjust OFFSET potentiometer A4R2 for time symmetry of the square wave.

4.10 SWEEP ZERO ADJUSTMENT

Connect the X-axis of a dc recorder (Moseley 136 or equivalent) to J23 (dc-proportional-to-frequency), BNC rear chassis connector.

Set the mode switch to SINGLE LINEAR SWEEP. Press the RESET DOWN pushbutton and set the LOWER SWEEP LIMIT for a frequency reading of 5 in the lowest decade range. Press the RESET UP pushbutton and set the UPPER SWEEP LIMIT for a frequency reading of 10 in the highest decade range.

Adjust the dc recorder, placing the pen at the left and right margins when in the DOWN and UP RESET modes, respectively.

Set the mode switch to AUTO LINEAR SWEEP and press the RESET DOWN pushbutton. Note the exact position of the recorder when it comes to rest.

Set the SWEEP RATE for 6 Hz/sec and MULTIPLIER (B) to 1.0 position. Momentarily press the SWEEP UP pushbutton. When the plotter pen has moved away from the left margin by an inch or so, momentarily press the SWEEP DOWN pushbutton. Note the amount by which the plotter pen undershoots or overshoots the "rest" position of the RESET DOWN mode (see previous paragraph). Repeat the UP and DOWN sweeps, adjusting ZERO potentiometer A7R21 for zero overshoot or undershoot.

4.11 SWEEP UPPER LIMIT

With the recorder still connected to J23, push the RESET UP button and note position on the recorder. Using the techniques described in paragraph 4.10, adjust TRANSFER potentiometer A7R51 for zero overshoot or undershoot.

4.12 LOG CONVERTER

*Remove and then reinstall circuit card A9 using the circuit card extender. Heat and disconnect one end of the jumper wire connected between A9E1 and A9E2. From an external power supply source apply, through an attenuator box, -10 Vdc to A1E2.

(Cont'd)

*4.12 LOG CONVERTER (Cont'd)

NOTE

If the output impedance of the external power supply is only a few ohms, install a 620Ω resistor in series with the output of the power supply and the input of the attenuator box. In addition, terminate the output of the attenuator box with a 620Ω resistor.

Attenuate and vary the level of the external power source from 0 dB to -dB and note the voltage change at A9TP4; attenuate and vary the level of the external power source from -50 dB to -60 dB and adjust A9R22 for the same incremental voltage change.

Set the level for 0 dB (-10 Vdc) and adjust A9R23 for 1.1 Vdc ±0.004 Vdc at A9TP4.

Attenuate the level to -60 dB and adjust A9R24 for 0.1 Vdc ±0.004 Vdc at A9TP4. Repeat the preceding adjustments until the following accuracies can be achieved:

INPUT dB	VOLTAGE AT A9TP4
0	1.100 Vdc, ±0.004 Vdc
-20	.767 Vdc, ±0.004 Vdc
-40	.433 Vdc, ±0.004 Vdc
-60	.100 Vdc, ±0.004 Vdc

Restore jumper connection between A9E1 and A9E2. Remove the extender card from receptacle J9 and reinstall circuit card A9.

4.13 LINEARIZATION

NOTE

The adjustments covered in this paragraph should be made with circuit cards A3 and A4 plugged directly into their receptacles. Do not use the extender card assembly. Adjust the capacitors with an offset screwdriver or similar tool.

Set MULTIPLIER (A) to the 1 position and the mode switch to MAN. With the voltmeter connected to J23, set the dc-proportional-to-frequency to 100 millivolts. Adjust FREQ potentiometer A2R33 for 10 Hz (period of 100 milliseconds) at J19, using a frequency counter. If A2R33 has insufficient range, change the value of resistor A4R1 as required.

Set MULTIPLIER (A) to the 10 position and adjust A4C6 for 100 Hz.

*Revised (10/12/71)

4.13 LINEARIZATION (Cont'd)

Connect an oscilloscope that has at least a 10 megacycle bandpass (Tektronix 545 or equivalent) to A4TP2 and set MULTIPLIER (A) to the 1 position.

Adjust A3C2 and A3C4 so that the amplitude variation of the triangle wave is minimized over a range of 1 Hz to 1000 Hz, and the variations in the positive and negative peaks are symmetrical with respect to circuit ground. Make sure that when the front panel meter indicates 1000 Hz, that the actual output frequency is 1000 Hz, plus 7 Hz, -0 Hz. If necessary, make further adjustment of A3C2 and A3C4.

Set MULTIPLIER (A) to the 10 position. Connect the oscilloscope to A4TP2 and adjust A3C1 and A3C3 so that the amplitude variation of the triangle wave is minimized over a range of 10 Hz to 10,000 Hz, and the variations in the positive and negative peaks are symmetrical with respect to circuit ground. Make sure that when the front panel meter indicates 10,000 Hz, that the actual output frequency is 10,000 Hz, +70 Hz, -0 Hz. If necessary, make further adjustment of A3C1 and A3C3.

Turn the unit off and note the position of the meter pointer, which should be resting exactly at 1. If necessary, adjust the mechanical control on the bezel of the meter. Turn the unit on and connect a frequency counter to rear connector J10 (Constant Amplitude Square Wave Output). Set the counter to read period.

$$\text{Period in Seconds} = \frac{1}{\text{frequency}}$$

In the MAN. mode and with MULTIPLIER (A) in the 1 position, adjust the FREQ and VERNIER controls for a meter reading of exactly 1. The readout on the counter should be between 98 and 102 milliseconds. Record the counter readout.

Change MULTIPLIER (A) to the 10 position and the readout on the counter should then be between 9.8 and 10.2 milliseconds. Record the counter readout.

If either reading on the counter, as recorded above, is out of the stated limits, select a different value for factory-adjust resistor A1R38 in parallel with A1R4. Note: Some instruments do not have resistor A1R38 installed. In that case, start with the installation of a resistor value of 40 to 100 ohms. Repeat the checks outlined in the two preceding paragraphs and further adjust the value of A1R38 as necessary.

Adjust the FREQ control for 100 millivolts at rear connector J23 and note that the meter indicates exactly 10, with the lowest decade indicator lamp illuminated. If necessary, adjust SERIES potentiometer A1R34 for the correct meter indication.

4.14 SINE SHAPER

The adjustment of the Sine Shaper, circuit card A8, will require a dual trace oscilloscope and a distortion analyzer (H-P Model 300D or equivalent).

With a soldering iron, heat and disconnect one end of the short buss wire jumper between A8E4 and A8E5.

Set the SD104A for 400 Hz, MAN. mode, with the MULTIPLIER (A) in the .1 position. Attach the distortion analyzer and oscilloscope probe to J19 (Constant Amplitude Sinewave Output). Adjust A8R26 so that the waveform has a nominal value of 2 to 3 volts peak-to-peak.

Distortion may be minimized by the adjustment of A8R10, A8R13, A8R19 and A8R21. Repeat the preceding adjustments and note the resulting distortion. If the distortion is not less than .3%, turn A8R19 ¼-turn clockwise and then optimize A8R10, A8R13 and A8R21. If the distortion is then lower than the previously noted reading, continue the adjustment of A8R19 in ¼-turn increments in a clockwise direction (optimizing A8R10, A8R13 and A8R21 each time) until no further improvement is noted.

If the preceding step does not improve the distortion, adjust A8R19 in ¼-turn increments in a counter-clockwise direction (optimizing A8R10, A8R13 and A8R21 each time) until no further improvement is noted.

Reconnect and solder the jumper between A8E4 and A8E5, and then adjust SHUNT potentiometer A8R4 for minimum distortion.

Attach the oscilloscope probe to A8TP3 and adjust A8R26 for exactly 3.5V p-p.

NOTE: For absolute minimum distortion, allow the instrument to warmup for approximately 1 hour with the top cover set in place but not screwed down. Remove the top cover and make a final readjustment of A8R4 and A8R13 for minimum distortion.

4.15 OUTPUT AMPLIFIER

Turn the front panel LEVEL control fully clockwise and connect an oscilloscope to the front panel OUTPUT jacks. Adjust the BAL potentiometer A11R24 so that the OFFSET control on the rear of the chassis will vary the offset of the sine wave variable output equally in a positive and negative direction.

4.16 HOLD DRIFT

Set the mode switch in the SINGLE LINEAR SWEEP position and press the DOWN RESET pushbutton. Start an UP SWEEP and depress the HOLD button while in the lowest decade range. After a period of two minutes, adjust A6R5 for minimum upward drift. Drift should be less than 2 millivolts per minute as measured at J23.

4.17 SWEEP TIME

Set the mode switch to SINGLE LINEAR SWEEP and the SWEEP RATE control to 10 (make sure dial is correctly zeroed). Set MULTIPLIER (B) to 10 and time a single UP sweep, which should have a duration of 49.95 seconds, ±0.5 seconds for a full 3-decade sweep. If necessary, adjust FAST potentiometer A7R72 for correct timing.

Set MULTIPLIER (B) to 1. Sweep time should now measure 499.5 seconds, ±5 seconds. If necessary, adjust SLOW potentiometer A7R75 for correct timing.

Return MULTIPLIER (B) to 10 and change mode switch to SINGLE LOG SWEEP. Time a single UP sweep, which should measure 18 seconds, ±0.1 second. If necessary, adjust LOG GAIN potentiometer A5R4 for correct timing.

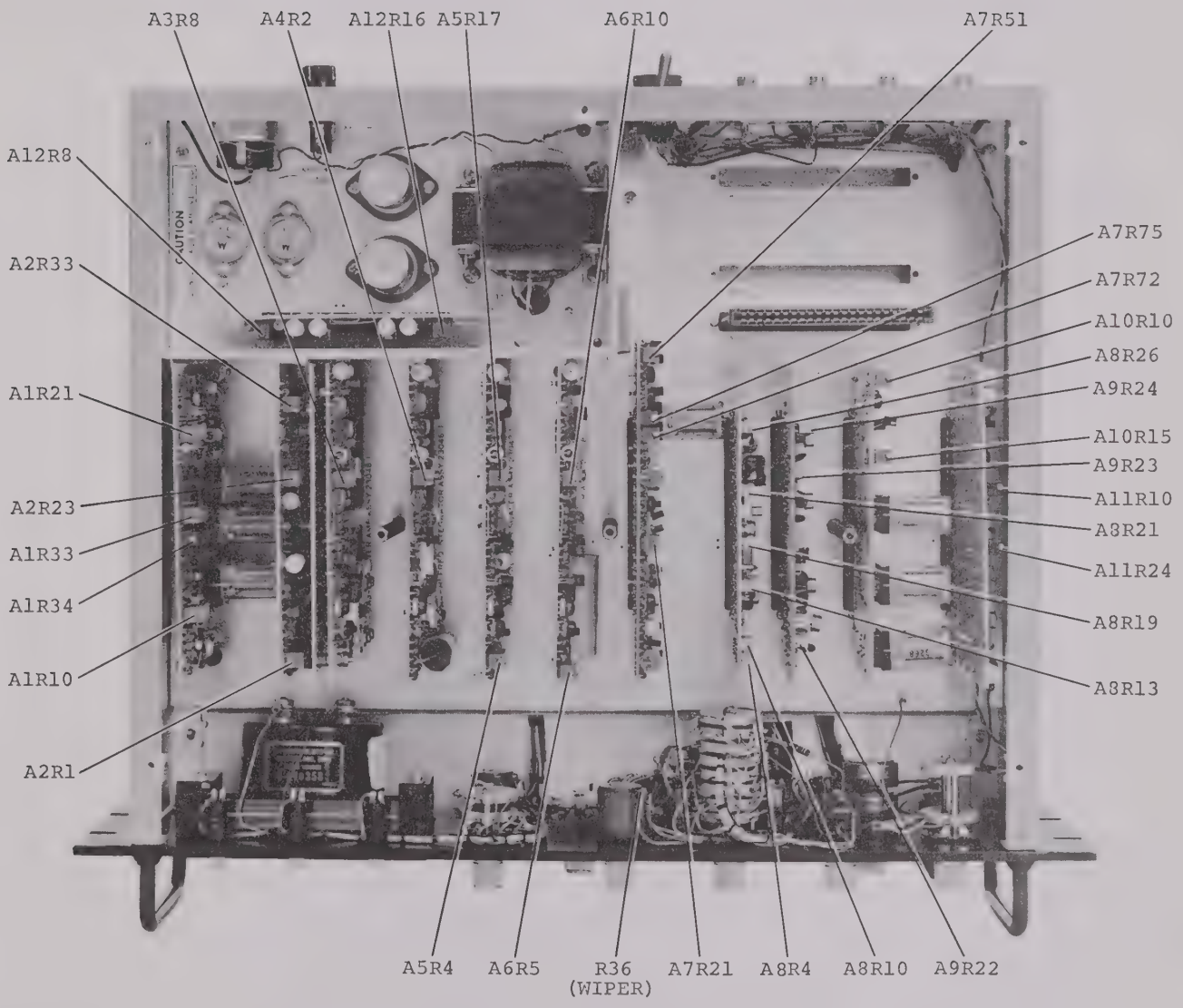


Figure 6. Top Chassis View

SECTION V

REPLACEABLE PARTS

5.1 GENERAL

Standard electronic components have been used in this instrument wherever possible. However, certain design features and innovations call for special components in some cases. A complete list of all the module type printed circuit card assemblies and special components are contained in this section.

Spectral Dynamics Corporation maintains a complete stock of all parts used in this instrument, as well as entire printed circuit card assemblies. When ordering replacement parts or assemblies, always include, in addition to any assigned stock number information listed below, a complete description of the item being ordered, the component reference designation and the model and serial number of the instrument.

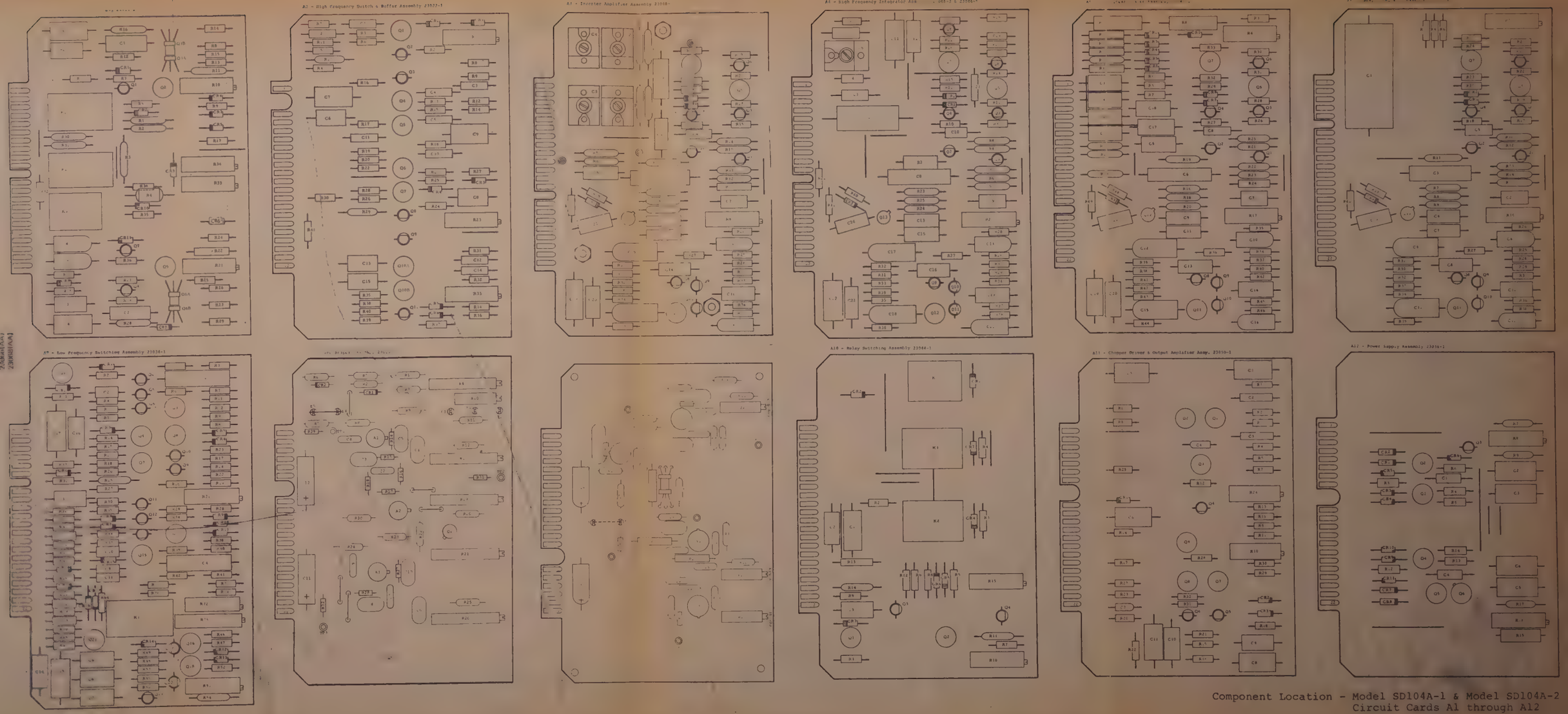
5.2 SPECIAL REPLACEABLE PARTS LIST

Reference Designation	Description	Part No. or Mfr. Desig.
A1	Meter Circuit Assembly	23024-1
A2	High Freq. Sw. & Buffer Assembly	23022-1
A3	Inverter Amplifier Assembly	23048-1
A4	High Freq. Integrator Assembly	23046-3
A5	Log/Linear Scaler Assembly	23042-1
A6	Sweep Integrator Assembly	23028-1
A7	Low Freq. Switching Assembly	23034-1
A8	Sine Shaper Assembly	23020-3
* A9	Log Converter Assembly	14056-1
A10	Relay Switching Assembly	23044-1
A11	Chopper Driver & Output Amp. Assy.	23050-1
A12	Power Supply Assembly	23036-1
A13	(not used)	
A14	(not used)	
A15	Circuit Card Extender Assembly	23060-1
DS1, DS3	Lamp, Indicator (Red)	CF03-RTB-2102
DS2	Lamp, Indicator (Yellow)	CF03-YTB-2102
DS4, DS5	Lamp, Indicator (Green)	CF03-GTB-2102
DS6, DS7, DS8	Lamp, Indicator (White)	CF03-WTB-2102
A9A1 A9A2 A9A3	Transistor, Potted Matched Pair (2N3391A)	23032-1
A1Q3A & A1Q3B A1Q6A & A1Q6B	Transistor, Matched Pair (cemented) (2N3391A)	20013-045

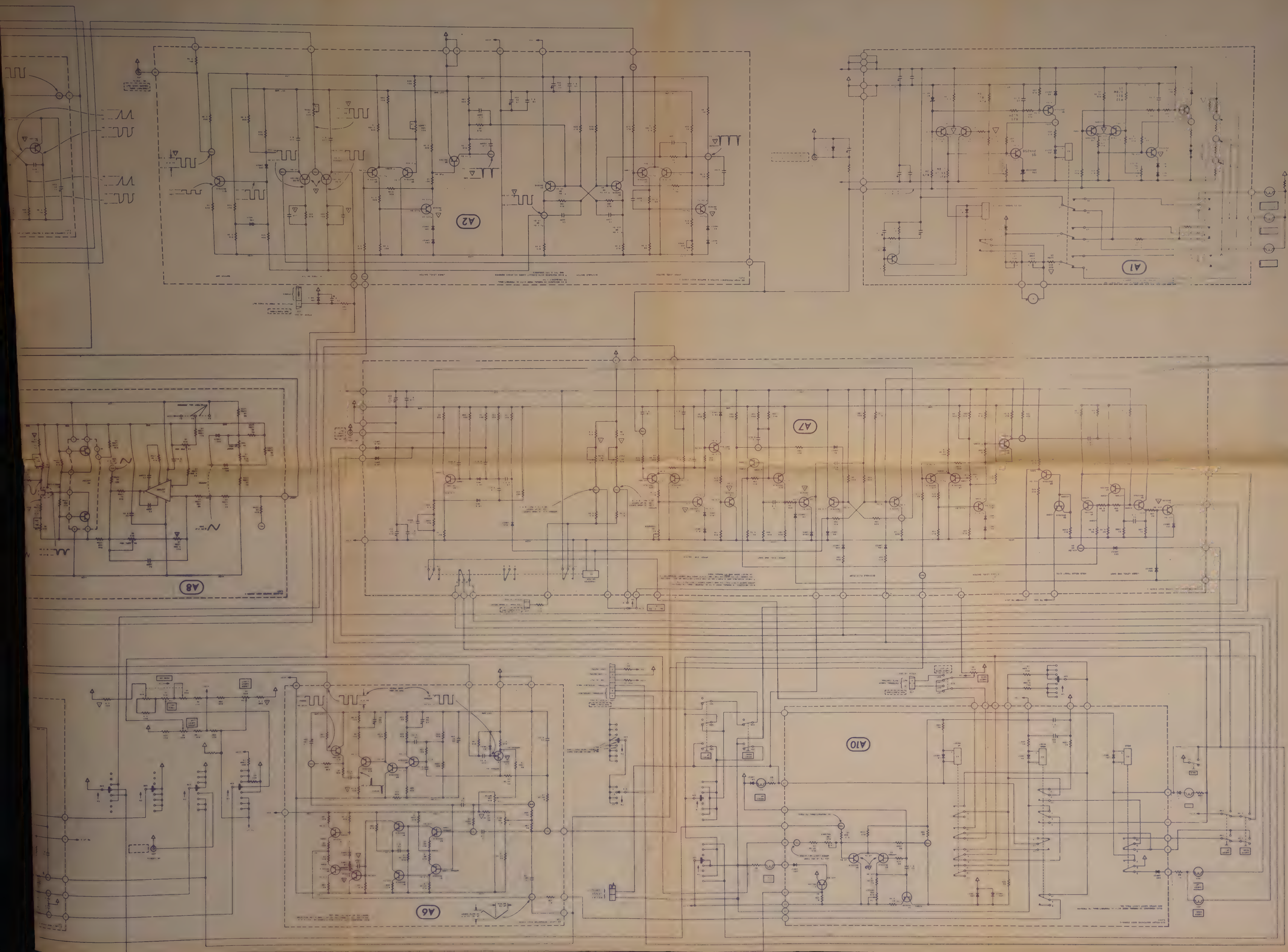
5.2 SPECIAL REPLACEABLE PARTS LIST (Cont'd)

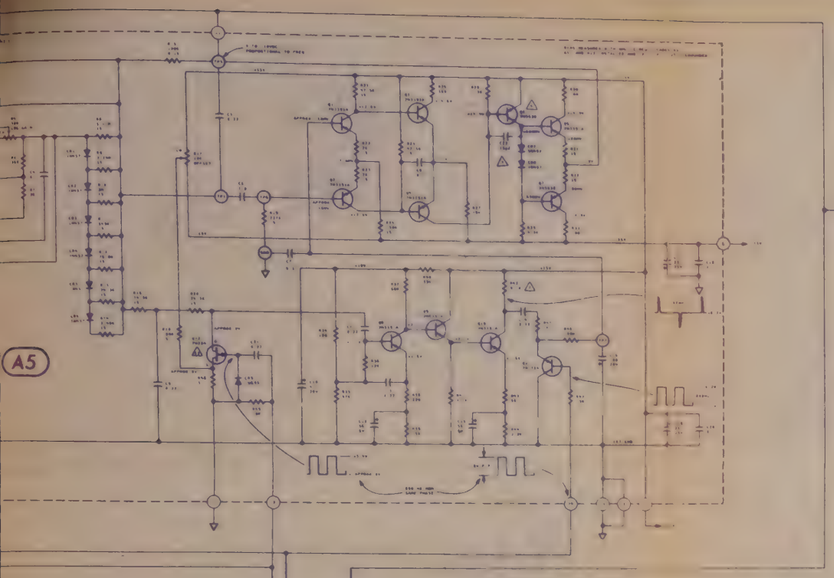
Reference Designation	Description	Part No. or Mfr. Desig.
A2Q10A & A2Q10B A11Q8 & A11Q9	Transistor, Matched Pair	20013-042
A2Q1, A2Q7, A3Q5, A5Q5, A6Q5, A7Q1, A7Q13, A7Q16	Transistor, Selected (2N3638)	20013-048
A1Q2, A1Q5, A4Q5, A7Q18,	Transistor, Selected (2N3638A)	20013-074
A11Q1, A11Q2	Transistor, Selected (2N1304)	20013-082
M1	Meter, Frequency	20013-281
S1	Switch, Multiplier (A)	20013-056
S2	Switch, Mode Selector	20013-054
S7	Switch, Function	20013-055
S13	Switch, Multiplier (B)	20013-072
R50	Potentiometer, Sweep Rate Multi-Dial, Sweep Rate Control	BOURNS 3500S-2-103 SPECTROL 11-1-11
T1	Transformer, Power	20013-060

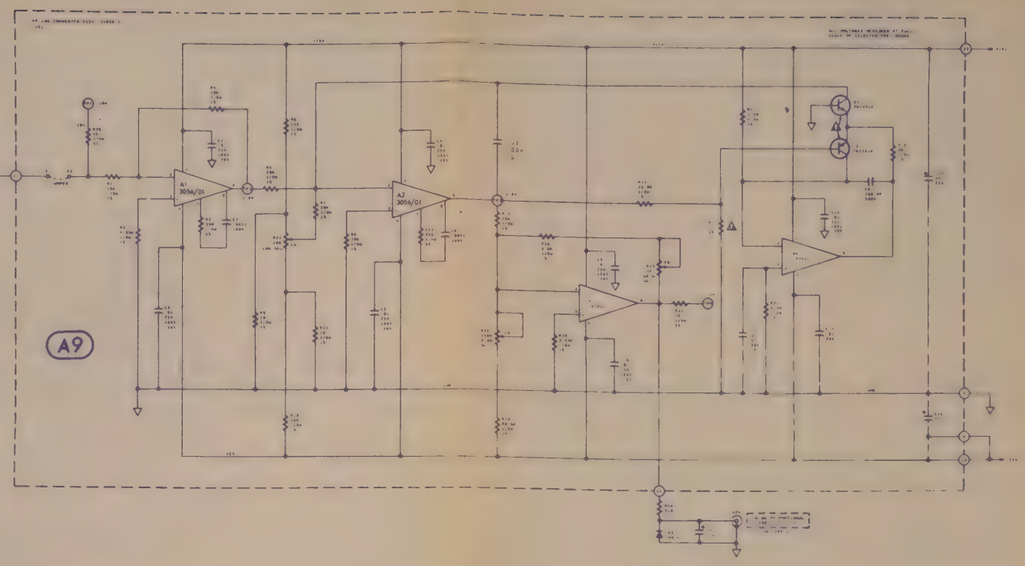
*Revised (10/12/71)

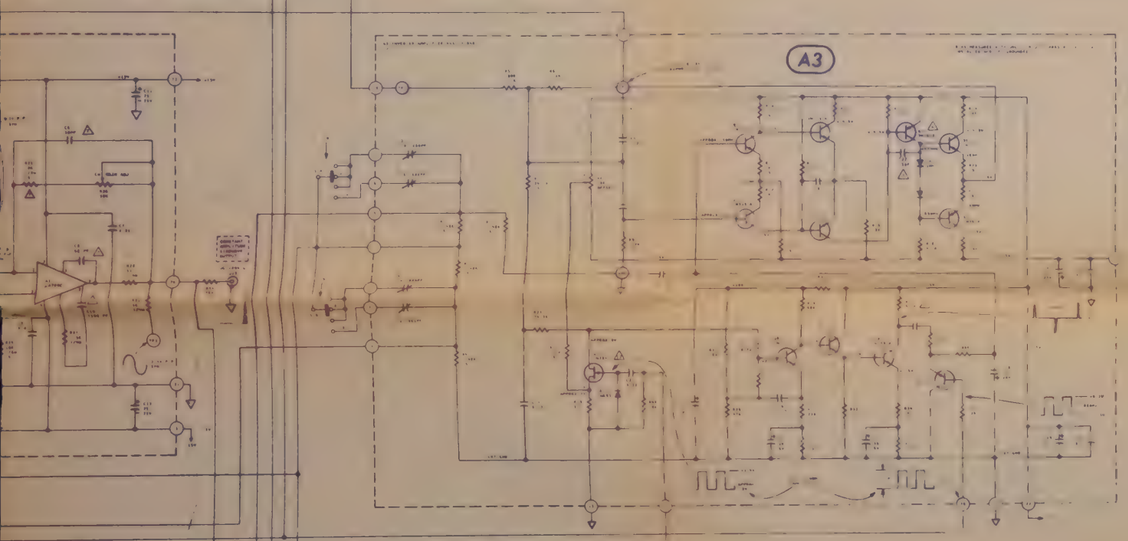


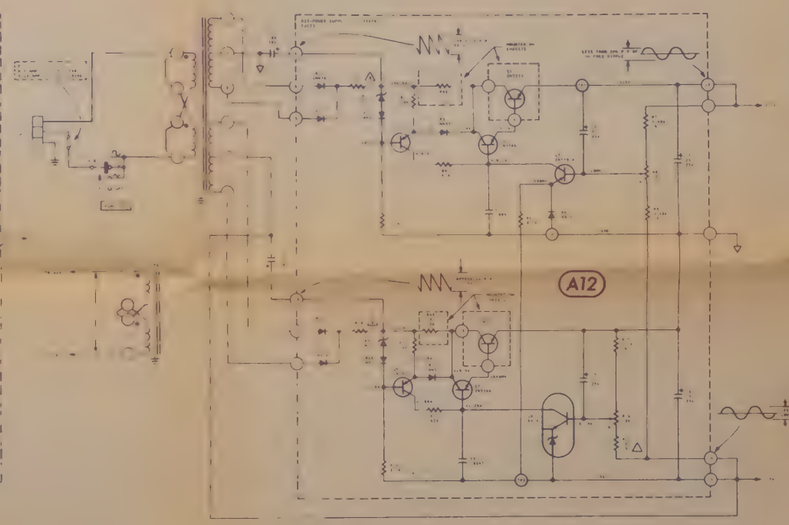
Component Location - Model SD104A-1 & Model SD104A-2
Circuit Cards A1 through A12

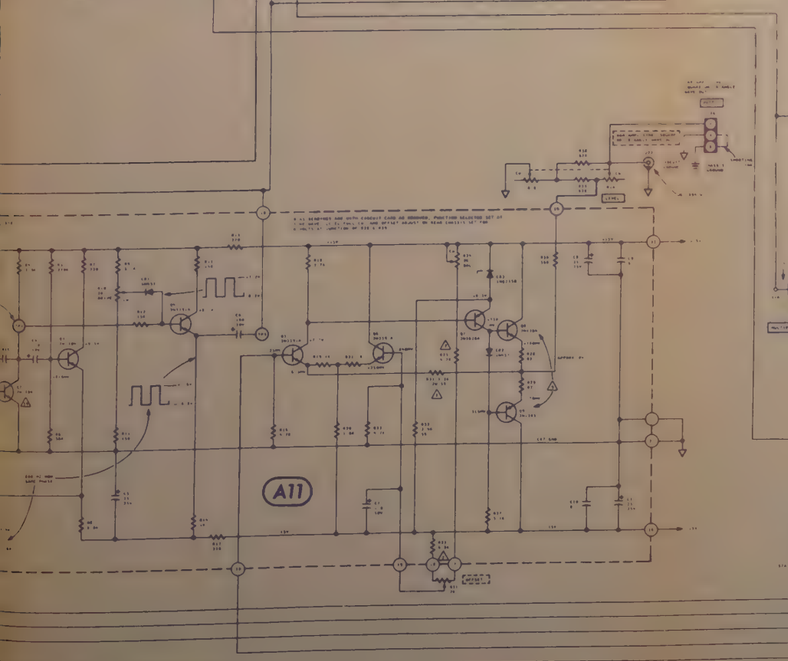

A1
A2
A6
A7
A8
A10

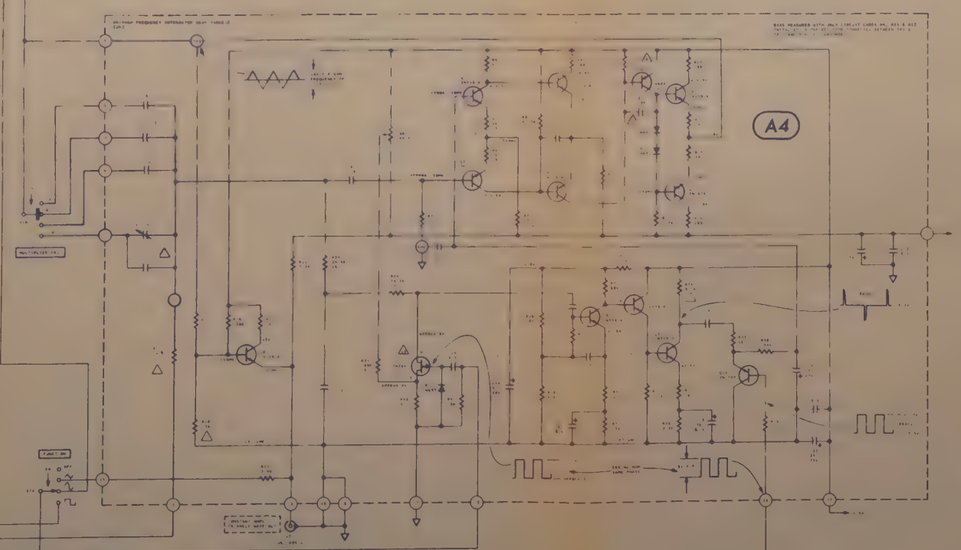












REVISIONS		
		DATE
M	REDRAWN EFFECTIVE S/N 353 6 OHM TYLER	
	WICKLAND	
A	INCORPORATED ECO 307 PRODUCTION EFFECTIVITY S/N 353 6 OHM WICKLAND	
L	INCORPORATED ECO 308 PRODUCTION EFFECTIVITY S/N 011 6 OHM WICKLAND	
M	INCORPORATED ECO 395 PRODUCTION EFFECTIVITY S/N 63 6 OHM WICKLAND	
N	INCORPORATED ECO 406 AND UPDATED THE HIGHEST REF DESIGNATOR BLOCK (AS EFFECTED BY THE SECONDARY MODIFICATION SCHEMATIC 1005-5 ADDING R55, R56 & R57. EFFECTIVITY S/N 413 & ON. WICKLAND	
U	INCORPORATED ECO 677 EFFECTIVITY S/N 1005	
V	INCORPORATED ECO 793 EFFECTIVE S/N 1060	
W	INCORPORATED ECO 780 EFFECTIVE S/N 1080	
X	INCORPORATED ECO 826 EFFECTIVE S/N 1198	
Y	INCORPORATED ECO 1019 EFFECTIVE S/N 1313	
Z		
AA		
AB	INCORPORATED ECO 1612 EFFECTIVE S/N 1588	

INPUT/OUTPUT CONNECTIONS

NOTES:

ASSEMBLY	MISCELLANEOUS REFERENCE DESIGNATIONS									
		CR	DS							
21020-1			4					5		
21022-1		15						22	23	
23024-1		8	11			5				
23028-1		4	3							
23054-1			19					21	24	
23056		6						6		
23056-1		14	9					20	25	
23062-1			8					12		
23064-1		1	7					4		
23066-1		24	3					13	27	
23068-1			1					17	26	
23070-1		16	3					9	32	
INTER CONNECT		12	5	5	8	10		1	2	34	13	1

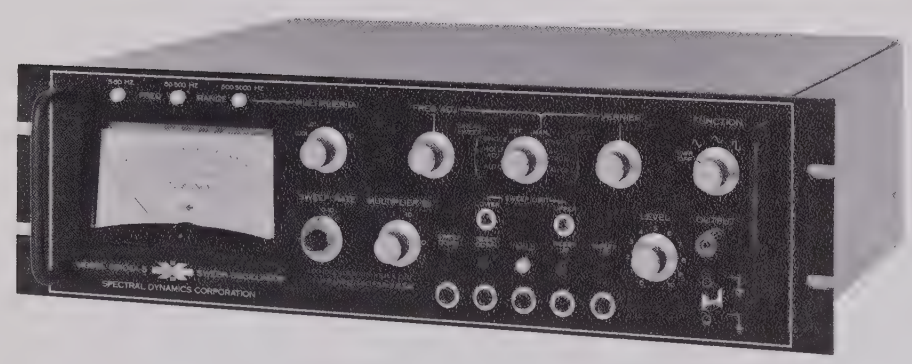
SPECTRAL DYNAMICS CORPORATION OF SAN DIEGO

SCHEMATIC INTERCONNECTING DIAGRAM - MODEL SD024A-1 SWEEP OSCILLATOR

DRAWN	M. N. TYLER	23066
APPROVED		
DATE	AUGUST 1966	SHEET

SD104 LINEAR/LOG SWEEP OSCILLATOR

APPLICATIONS



- FREQUENCY RESPONSE PLOTTING
- DC HYSTERESIS TESTING
- FOURIER ANALYSIS
- POWER SPECTRAL DENSITY ANALYSIS
- STEPPED FREQUENCY SCANNING
- VIBRATION TESTING
- FATIGUE TESTING
- DC LOG CONVERSION
- MEDICAL STIMULATION
- ORDER FOLLOWING AND ANALYSIS

SPECTRAL DYNAMICS CORPORATION OF SAN DIEGO
POST OFFICE BOX 671, SAN DIEGO, CALIFORNIA 92112
TELEPHONE 714—278-2501 • TWX 910-335-2022

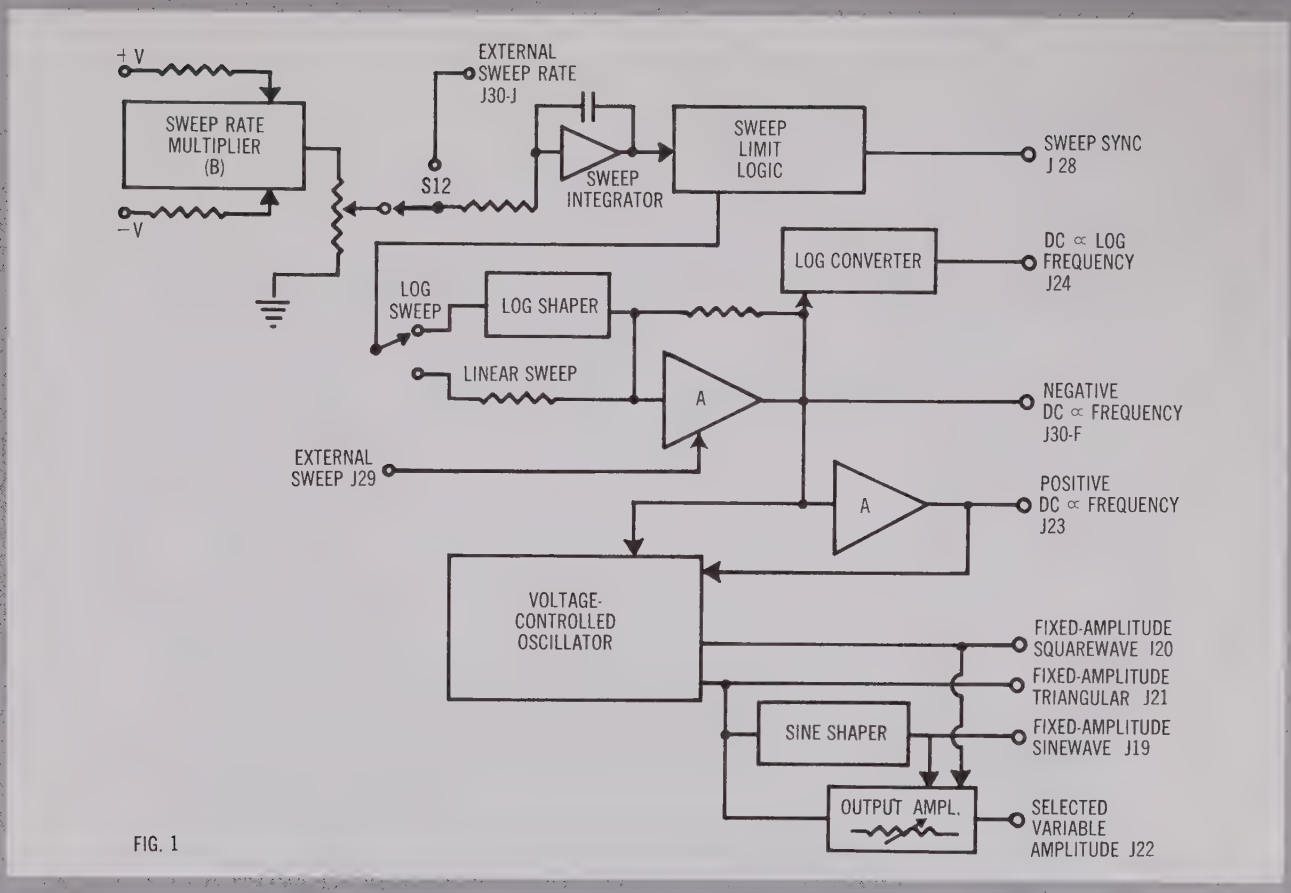


FIG. 1

BLOCK DIAGRAM: SD104 SWEEP OSCILLATOR

GENERAL

The SD 104 Sweep Oscillator is an all-electronic, solid-state instrument with remarkable adaptability to a variety of applications. This is due in part to voltage control of important frequency and sweep parameters. Referring to Figure 1, above, it is seen that the SD104 is essentially a sweep generator coupled with a wide-range voltage controlled oscillator.

In the internal sweep mode, an adjustable, internal DC voltage drives an operational sweep integrator. When the pre-selected sweep limit is reached, either the sweep is stopped or the direction of sweep is reversed, depending on whether single or repetitive sweep has been selected. The voltage from the sweep generator, applied to the voltage controlled oscillator, is permitted to swing between 10 millivolts and 10 volts. This 3-decade voltage limit is made to correspond exactly to a 3-decade frequency sweep.

For example, with the SD104A-5, a 7-decade frequency range is available. A given 3 decades—such as 5 Hz to 5,000 Hz, or 50 Hz to 50,000 Hz, or a portion of this range can be swept linearly or logarithmically with respect to time.

External inputs are available both to the sweep integrator *J-30J* and directly to the voltage controlled oscillator *J29*. Thus the sweep rate, direction and limits may be remotely controlled and, in addition, arbitrary FM wave-forms may be generated. A 3-volt half-millisecond sync pulse is generated each time a sweep is initiated or sweep direction is reversed. Fixed amplitude sine *approx. 1 V rms,* square *approx. 5 volts p-p* and triangular *approx. 5 volts p-p* waveforms, variable amplitude *0 to 10 volts p-p* sine, square or triangular waveforms; and DC voltages proportional to linear *0 to 10 V and 0 to -10 V* and logarithmic *0 to IV* output frequency are furnished as standard outputs.

Constant amplitude, *1V rms approx.*, fixed phase, *0°, 90°, 180° and 270°*, sinewave outputs are available as an extra cost option. This option, *identified as "dash p" suffixed to the standard model number,* provides an accuracy of ±3° of stated phase difference from 2 Hz to 50 kHz.

Noise level of the SD104 is at least 80 dB below full output.

Three standard models of the SD104 are available: the SD104-1, SD104-2 and SD104-5. Functionally identical, they differ only in their total frequency range of operation. (See the SD104 Data Sheet for specific differences.) A recent version of the SD104—the SD104A series—features a more conveniently located power switch and the inclusion of protective "interlock" circuitry designed for use with the SD105 Amplitude Servo/Monitor. The applications described on the following pages are valid for both the SD104 and SD104A series Linear/Log Sweep Oscillators.

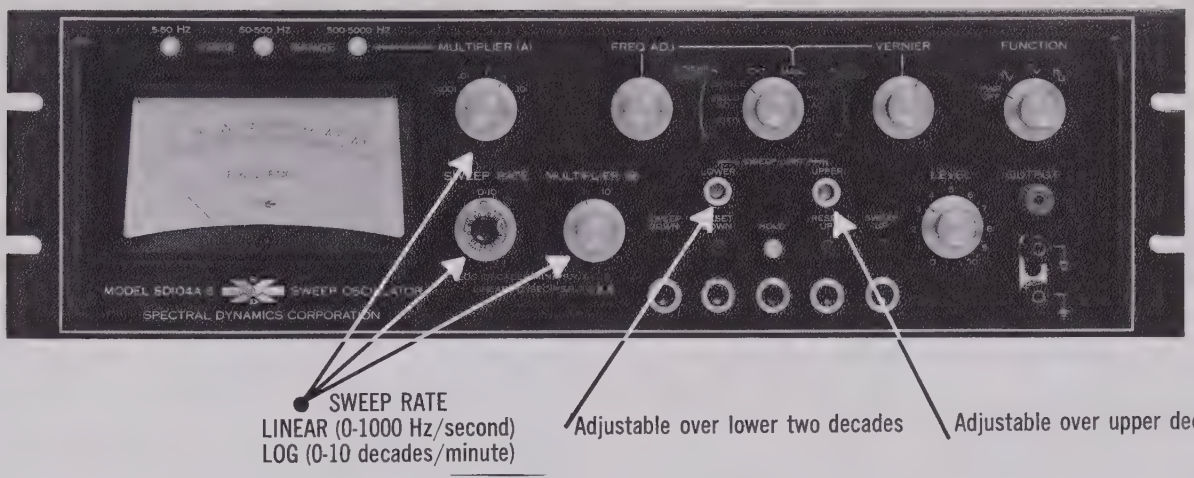


FIG. 2 *SD104 FRONT PANEL*

DESCRIPTION/FUNCTION

J30 Pin	
A & B	External series-interlock connections. Used for connection to the interlock circuitry of a vibration exciter control servo or system cabinet.
C	Interlock/Hold. For use with external interlock circuitry.
D	+15 volts dc, regulated. Source impedance 1000 ohms. Short-circuit proof.
E	−15 volts dc, regulated. Source impedance 1000 ohms. Short-circuit proof.
F	Negative 0 to −10 volts dc linearly proportional to output frequency.
G	Circuit ground.
H	Sweep control voltage from internal sweep circuit. Connected internally to Sweep Integrator when S12 is in the INT position.
J	Input to the Sweep Integrator circuit. Used for external control of sweep rate and direction. Maximum permissible input voltage is positive or negative 10 volts dc. Input impedance 1.8 megohms in LOG mode; 5 megohms in LINEAR mode.
L	Positive or negative 15 volts dc, regulated depending on direction of sweep. Negative 15 volts dc for UP SWEEP; positive 15 volts dc for DOWN SWEEP.

Current drawn from J30-L must not exceed 50 milliamps. A short circuit will not damage the instrument but will cause it to be inoperative until the short is removed.

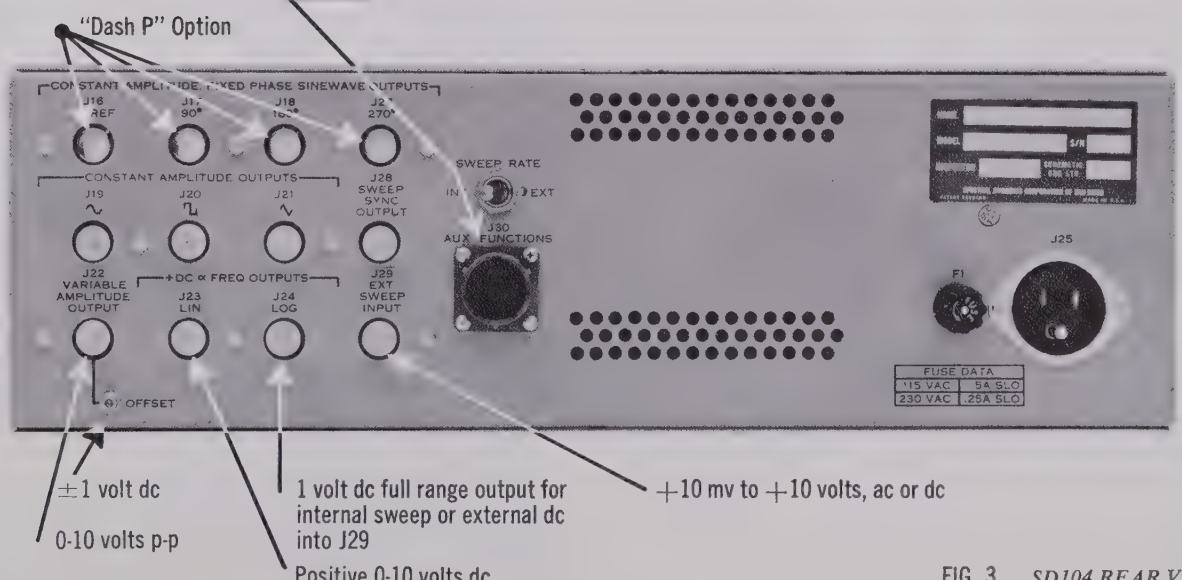


FIG. 3 *SD104 REAR VIEW*

FREQUENCY RESPONSE PLOTTING

PROBLEM Determine and automatically plot the magnitude transfer function of an arbitrary electronic circuit in minimum time.

SOLUTION *Figure 4:* Apply the constant amplitude sinewave output of the SD104 directly to the input of the circuit under test. Select the desired 3-decade sweep or a portion thereof from the 7-decade frequency range available. Connect the DC proportional to frequency, *linear or log,* to the abcissa of the X-Y recorder. Rectify the AC output of the circuit under test, and use this DC signal to drive the ordinate of the X-Y recorder. Select "single linear sweep" mode and a sweep rate sufficiently slow to allow for "high Q" buildup in the circuit under test. *Note that for a circuit with a "constant Q" type characteristic, a single log sweep may be preferable.* Now, as an automatic sweep is initiated, the desired frequency response is plotted directly, automatically.

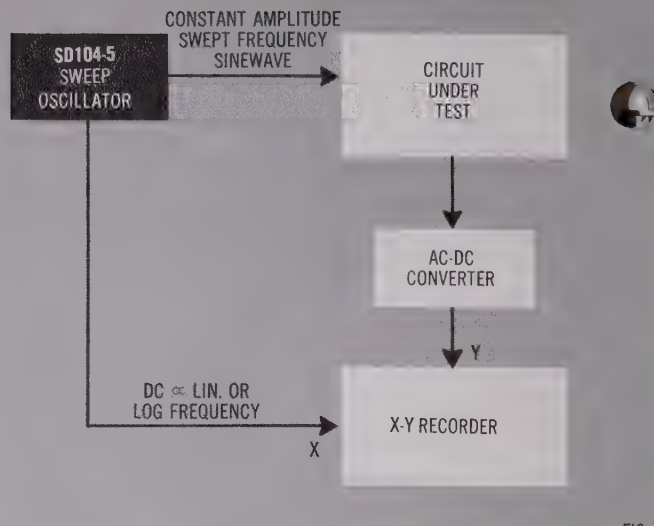


FIG.

"FUNDAMENTAL ONLY"
FREQUENCY RESPONSE PLOTTING

PROBLEM Determine and plot automatically the "fundamental only" frequency response of a nonlinear circuit or other type of network which produces harmonics or distortion products in addition to a fundamental frequency component.

SOLUTION *Figure 5:* It can be seen that the achievement of true magnitude transfer function requires only the use of selective filtering in addition to the frequency-response plotting setup shown in Figure 4. The use of a Spectral Dynamics SD101A electronic tracking filter in the signal path between the output of the test circuit and the ordinate input of the X-Y recorder, provides an AC filtered signal and a DC signal proportional to the amplitude of the narrowband filtered fundamental response of the circuit being investigated. Once again, a completely electronic "hands off" display is provided with selective filtering furnished through plug-in crystal filters.

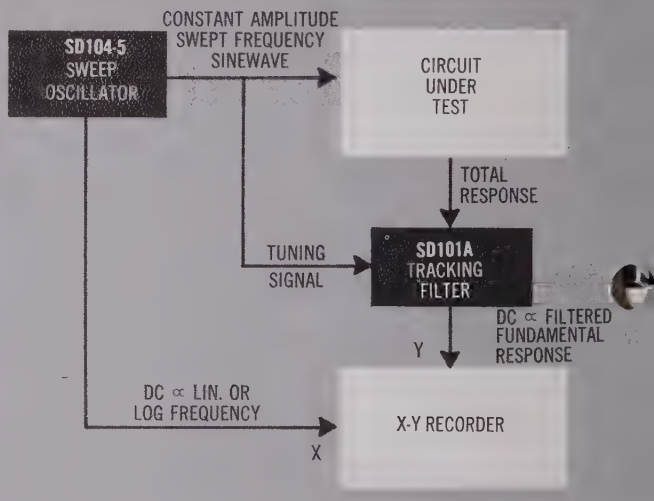


FIG.

DC HYSTERESIS TESTING + PLOTTING

PROBLEM Determine and plot automatically the "hysteresis" or variation in output of a relay or switching circuit, DC amplifier etc. due to a varying DC applied in a bidirectional sweep fashion.

SOLUTION *Figure 6:* Apply the DC proportional to linear frequency to the circuit under test and to the X axis input of the X-Y recorder. Apply the output of the tested circuit to the Y axis of the X-Y recorder, and scale both axes for a full-range display of the area of interest.

Select "automatic linear sweep," and sweep up from the "Reset Down" condition. Note that for this type of test only the DC output of the SD104 is used to test the response of a DC circuit to both increasing and decreasing potentials.

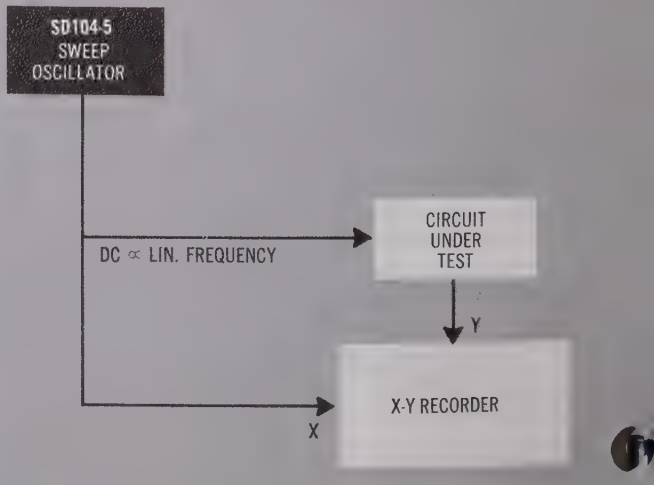


FIG. 6

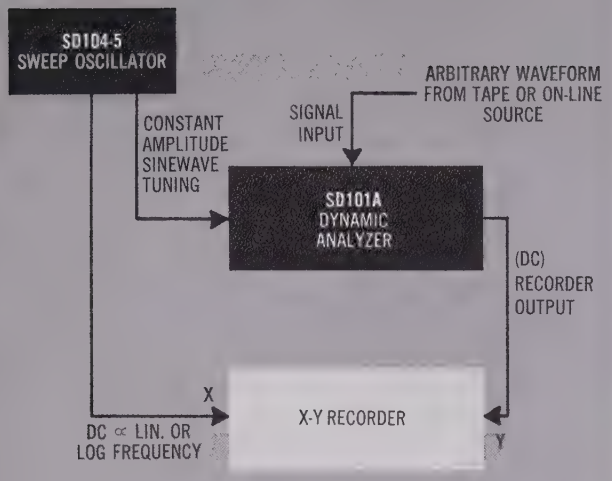


FIG. 7

FOURIER SPECTRUM ANALYSIS

PROBLEM Determine and display automatically the Fourier components of a periodic signal or the general spectral content of an arbitrary waveform.

SOLUTION *Figure 7:* Apply the waveform under analysis to the Signal Input terminals of a SD101A Dynamic Analyzer and the constant-amplitude sinewave output of the SD104 to the Tuning Signal terminals of the SD101A. Connect the DC proportional to linear or log frequency to the X axis of an X-Y recorder and the Recorder Output of the SD101A to the Y axis. Adjust for the frequency range of interest and select "single linear sweep". Install a plug-in crystal filter of the required selectivity in the SD101A and initiate a sweep. As the sweep progresses, the spectrum content of the arbitrary signal is automatically recorded for further analysis.

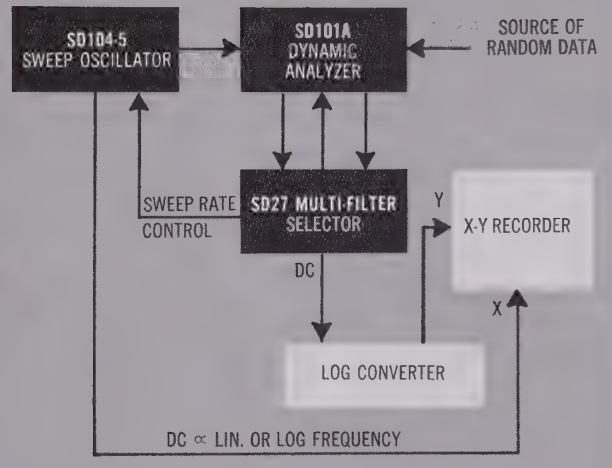


FIG. 8

POWER SPECTRAL DENSITY ANALYSIS

PROBLEM Perform an optimum analysis and automatic display of the Power Spectral Density associated with an arbitrary random waveform.

SOLUTION *Figure 8:* PSD parameters such as sweep rate, averaging time, filter normalizing and crossover frequencies are preset in the SD27 Multi-Filter Selector. As a frequency sweep progresses, filter bandwidths are increased at preselected points and averaging time, bandwidth division and SD104 sweep rate are controlled automatically. Log amplitude, A^2/Hz, is displayed, providing maximum dynamic range, and statistical confidence is maintained at an optimum level throughout.

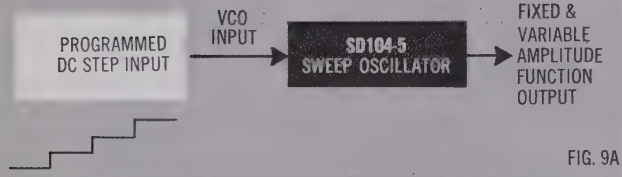


FIG. 9A

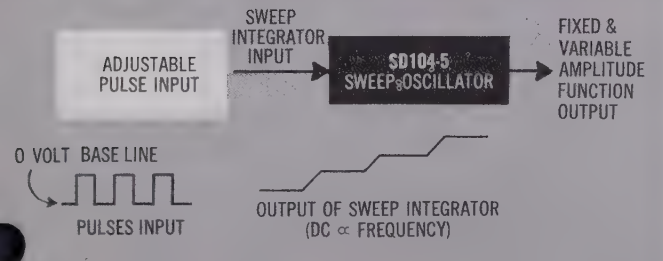


FIG. 9B

STEPPED FREQUENCY SCAN

PROBLEM Furnish a function generator output, *sine, square and triangular waveforms,* which may be made to step forward or backward in frequency, automatically, as a function of an external control voltage. Such a signal is very useful in a spectrum analysis system. With it the analyzer is made to step forward in frequency by one filter bandwidth for each revolution of a tape loop; or the stepped frequencies can be made to correspond exactly to the center frequencies and band edges of a bank of filters or discriminators.

SOLUTION *Figures 9a and 9b:* Inputs are available to both the sweep integrator and to the voltage controlled oscillator in the SD104. Thus a stepped frequency output can be achieved either by application of a programmed DC ramp step voltage directly to the VCO or by the application of "zero-base" pulses to the sweep integrator.

SINEWAVE VIBRATION TESTING

PROBLEM Furnish a stable, programmable, fixed frequency or automatically swept sinewave to an amplitude servo for performing a preprogrammed sinewave vibration test. At the same time, furnish an accurate DC voltage proportional to output frequency for use in automatic filter bandswitching and for driving the abcissa of an X-Y recorder.

SOLUTION *Figure 10:* The constant amplitude sinewave output of the SD104 is applied to the tuning signal input of the SD101A Tracking Filter and to the reference audio input of the SD105 Amplitude Servo/Monitor. At the same time, the DC voltage proportional to log frequency output of the SD104 is applied to the bandswitching unit of the SD101A Tracking Filter and to the abcissa of the monitoring X-Y recorder. Sweep limit frequencies and sweep mode are set into the SD104, test parameters are preset into the SD105 and a sweep initiated.

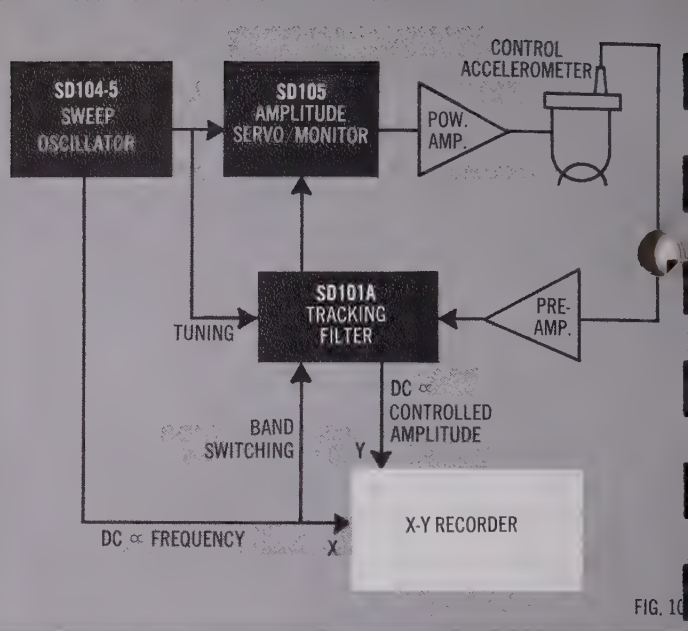


FIG. 10

FATIGUE TESTING AND RESONANCE PHASE LOCK

PROBLEM Determine automatically, conditions of resonance of a structure under test and automatically maintain resonance even under conditions of dynamic package variation.

SOLUTION *Figure 11:* At resonance there is a 90° relationship between applied force and resultant acceleration at a point. Thus a condition of 90° between force and acceleration can be set up on a phasemeter before a test is begun, using an impedance head. The DC voltage proportional to phase output of the phasemeter is then bucked with the DC voltage available from the SD104 and this null voltage applied to the sweep integrator (external) input of the SD104. During a sinewave sweep vibration test, as a condition of 90° is approached, the SD104 is simply switched from internal to external sweep. The approaching null into the sweep integrator stops the sweep and maintains that frequency which produces a 90° reading. Even as package dynamics change due, for example, to fatigue, the loop will "follow" the resonant frequency. By changing the sense of the phasemeter inputs, antiresonance and resonance can be searched automatically by allowing the SD104 to externally seek a null point. Note that this technique can also be applied to a temperature, velocity or amplitude etc. feedback signal.

This application is particularly useful for extended-time fatigue testing in that once the test is started, an operator is not required to monitor the test continuously to maintain excitation at resonance. The system could be extended to include an automatic shutdown in case of specimen failure.

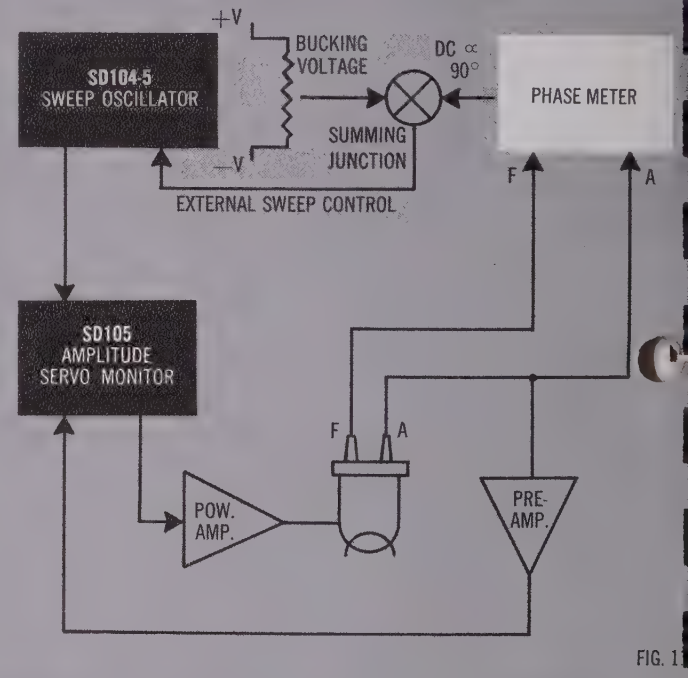
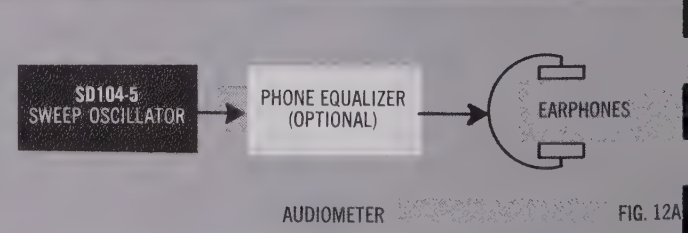


FIG. 11

MEDICAL STIMULATION/SYSTEM EXCITATION

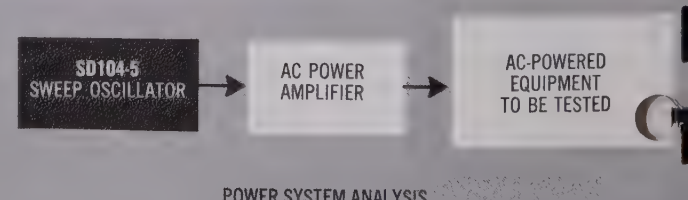
PROBLEM Furnish an AC source slowly varying in frequency about a power frequency to simulate inverter runaway etc; provide a swept audio source for testing human audio response. In general, furnish a versatile AC signal suitable for stable, single-frequency operation or swept-frequency functioning.

SOLUTION *Figures 12a, 12b:* The wide range of sweep rates available with the SD104 permits: (a) extremely slow frequency change for power system excitation or (b) relatively rapid frequency sweep as a stimulus in audio response testing. The "flat" frequency response of the SD104, *within ±0.2 dB over its entire frequency range,* assures a constant voltage input to the system or earphones being excited, although an equalizing network is sometimes desired to maintain constant power input.



AUDIOMETER

FIG. 12A



POWER SYSTEM ANALYSIS

FIG. 12B

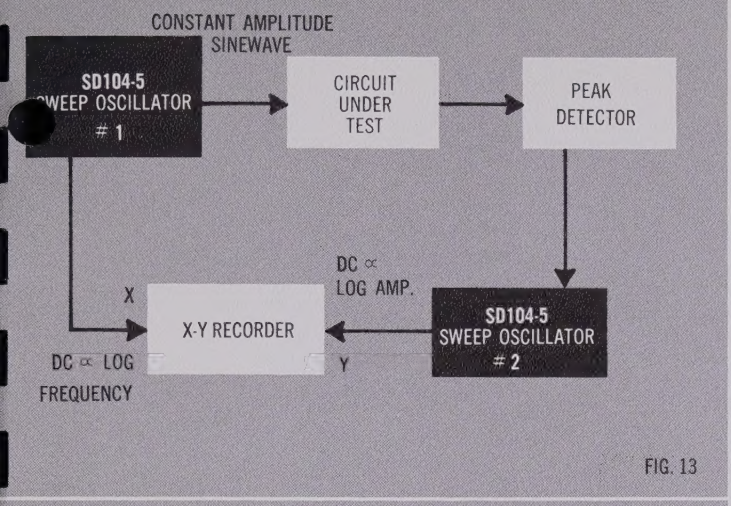


FIG. 13

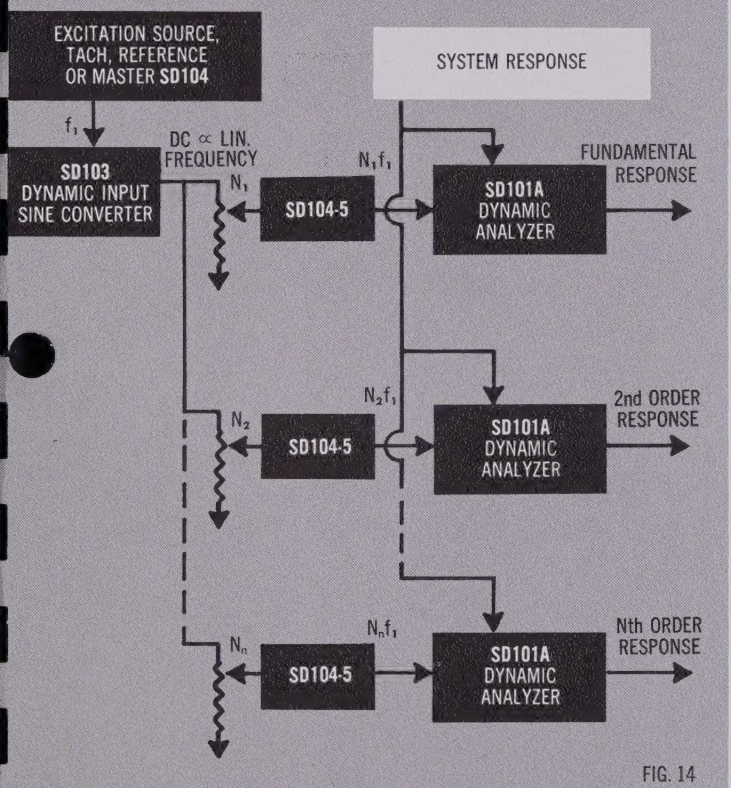


FIG. 14

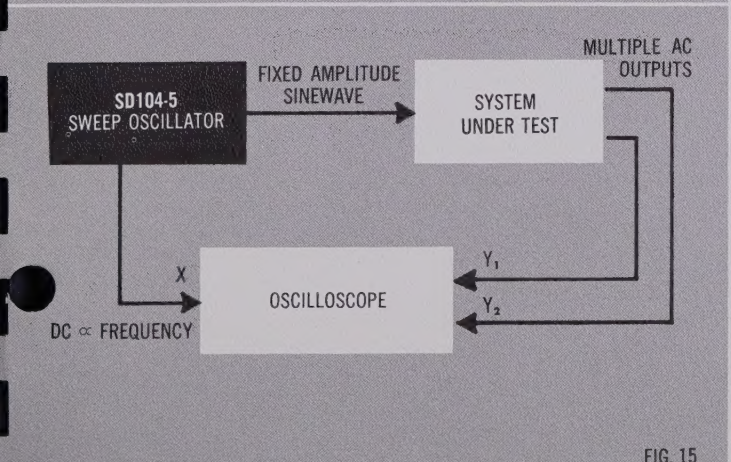


FIG. 15

DC LOG CONVERSION AND AUTOMATIC LOG-LOG PLOTTING

PROBLEM Convert a detected DC level to its corresponding log value for direct presentation in terms of dB with optimum resolution.

SOLUTION *Figure 13:* Placing the mode switch of the SD104 in the "external" position, provides an input directly to the voltage controlled oscillator and to the log converter. In this mode, the output of J24 is the logarithm of the DC potential applied to J29. The log conversion function of the SD104 operates over a 60 dB dynamic range with an accuracy of ±1/4 dB. This test configuration permits, for example, rapid production testing of high-fidelity amplifiers. If the log DC proportional to frequency of the master SD104 is used to drive the abcissa of the X-Y recorder and the log amplitude DC from a second SD104 is applied to the plotter ordinate, an automatic log-log display indicating the decibel response of the amplifier is produced.

ORDER FOLLOWING AND ANALYSIS

PROBLEM Display automatically the fundamental and harmonic order response of a complex or nonlinear system as a function of a changing excitation frequency. Determine the harmonic content of a circuit or system as the input frequency is varied.

SOLUTION *Figure 14:* As a first step, a DC voltage proportional to linear excitation frequency is formed in the SD103. *If a master SD104 is used for system excitation, the SD103 and "fundamental" SD104 are not required, since the master SD104 serves both purposes.* This DC proportional to frequency is then put through a multi-turn potentiometer and the potentiometer wiper output used to generate a frequency directly from the following SD104s which are operating in the external mode. The slaved SD104s may then be made to produce harmonics or subharmonics of the master source and automatically track, maintaining the preset ratio, the master source. The tracking sinewave outputs may then be used to tune corresponding tracking filters for complete "harmonic only" analysis. Using the SD103 from an arbitrary source input, a fundamental frequency range of 10 Hz to 10 kHz is available. The actual ratio, N, which may be achieved between reference tach frequency input and SD104 "following" output is a function of the range setting used on the SD103 and SD104. For example, if the 10Hz to 2kHz range of the SD103 is used, and the SD104 is placed in the X1 position, the configuration depicted in Fig. 14 will permit a variation in N from O to approximately 2.4. With the SD104 in the X10 position, this becomes approximately 24. If a "master SD104" is used the total frequency range of tracked sinewave available is from 0.005 to 50,000 Hz. *See SD101A Date Sheet for SD101A frequency response.*

OSCILLOSCOPE SWEEP AND OBSERVATION

PROBLEM In situations where several AC outputs of a device under test must be monitored simultaneously, a means is required for obtaining a rapid display, calibrated in terms of excitation frequency.

SOLUTION *Figure 15:* The DC proportional to linear frequency output of the SD104 is applied to the external sweep input of a standard oscilloscope. The signals to be monitored are connected to the inputs of a multi-channel preamp plug-in. The scope abcissa is calibrated by simply adjusting the upper and lower sweep limits of the SD104 in conjunction with the "reset up" and "reset down" controls. Upon initiating an automatic linear or log sweep, the envelope of the response signals is clearly displayed as a calibrated spectrum presentation.

SPECIAL SD104 CONFIGURATIONS

A. FAST SWEEP

PROBLEM (1) Rapidly sweep the frequency range of interest of a device under test at a precisely set sweep rate and record and observe the frequency response of the device or (2) define the slewing rate of an electronic or electromechanical device as a function of a sweep frequency input.

SOLUTION *Figure 16:* Special, fast sweep, versions of the SD104 are available. For example, the SD104A-5FS1 Oscillator includes a special printed-circuit card and toggle switch to provide a sweep which is nominally 100 times as fast as normal. It provides linear sweep rates from 0 to 100,000 Hz/sec and log sweep rates from 0 to 1,000 decades/min., when the toggle switch is in "Fast Sweep" position. By returning the switch to "Normal" the oscillator functions as a standard SD104-5.

B. TRIGGERED SWEEP

PROBLEM Provide a frequency sweep which is synchronized to an external stimulus and which can then be correlated to concurrent external events.

SOLUTION *Figure 17:* Special, triggered versions of the SD104 are available which, when excited by an external pulse, provide a frequency sweep over preset frequency limits at a preset sweep rate. At the end of this remotely controlled, sawtooth frequency sweep, the oscillator output is blanked until a new trigger pulse initiates a fresh sweep.

C. AMPLITUDE MODULATED OUTPUT

PROBLEM Accept a carrier signal of specified frequency and furnish this carrier, amplitude modulated by a swept frequency sinusoid. For example, using a 400 Hz carrier, check aircraft servo response or using a different carrier frequency investigate performance and response of any carrier system.

SOLUTION *Figure 18:* A special, modulated output version of the SD104 is available. Requiring a reference carrier signal at a frequency specified by the user, *nominally of frequency at least 4 times as high as the highest modulating frequency to be used,* two operational modes are furnished. In one mode, the modulated output is available at all times. In the second mode the modulated output is zero in either UP or DOWN reset. A modulated output is then available, starting at the zero axis crossing of the modulating waveform when a sweep UP or DOWN is initiated.

D. MULTI RANGE VERSION

PROBLEM In one sweep oscillator furnish several operational frequency ranges. Thus permit an automatic sweep from 5 to 5000 Hz for sinewave vibration testing, 10 to 10,000 Hz for many PSD analyses and 20 to 20,000 Hz for acoustic response testing.

SOLUTION *Figure 19:* The SD104-10 offers 10 three-decade sweep ranges in one oscillator. With a frequency scale calibrated from 1 to 1,000, ten multipliers, *covering the range 0.02 to 20,* are supplied. A total frequency range from 0.02 to 20,000 Hz is thus available. This technique can also be adapted to include an upper frequency scale of 50,000 Hz.

E. 4-PHASE/VARIABLE-PHASE OUTPUT

PROBLEM Obtain simultaneous sin θ, cos θ, -sin θ and -cos θ signals corresponding to 0°, 90°, 180° and 270° sinusoids, and a continuously variable phasor output over a wide frequency range.

SOLUTION *Figure 20:* The SD104-5 P provides four fixed phase constant amplitude outputs, over a frequency range of 1Hz to 50 kHz. The addition of a weighted, twin, continuous potentimeter furnishes a continuously adjustable phase output in addition to the fixed phase outputs over the entire frequency range of 1Hz to 50 kHz.

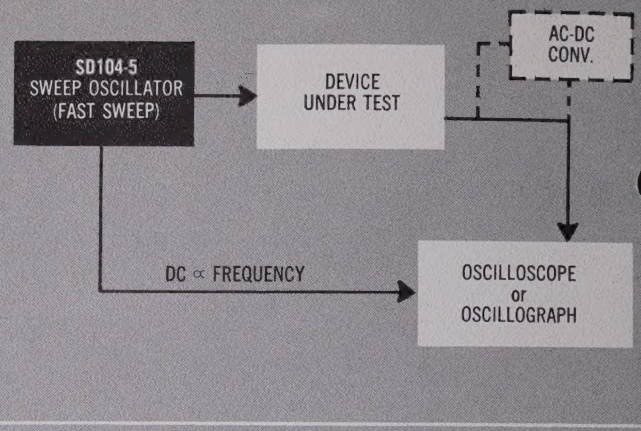


FIG.

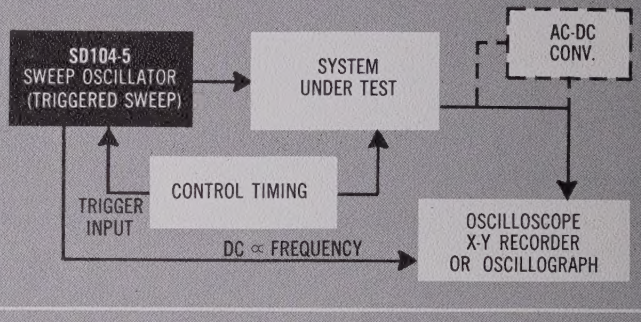


FIG.

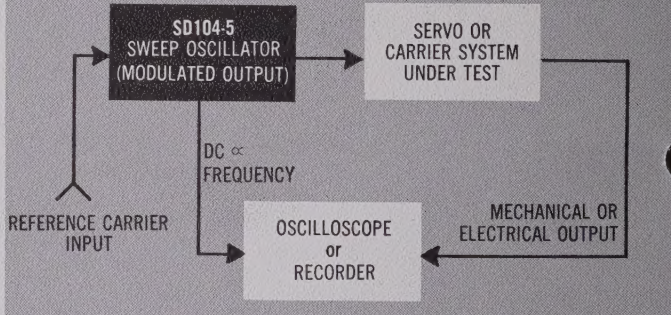


FIG.

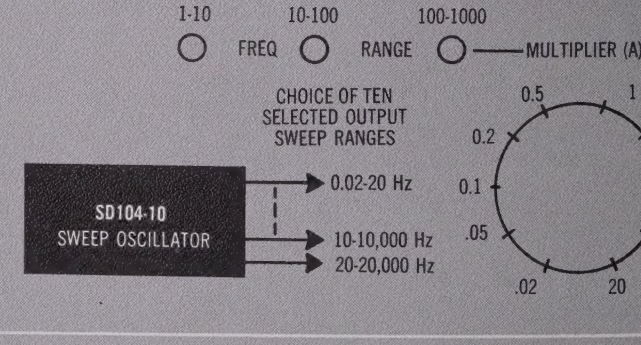


FIG.

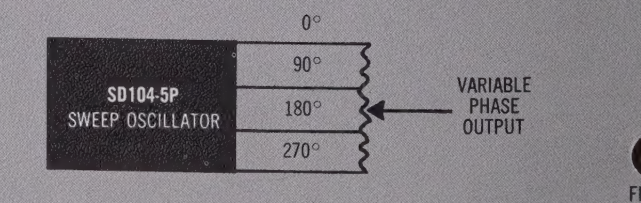


FIG. 20

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